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Report of the

TWENTY-FIFTH SOUTHERN PASTURE AND FORAGE CROP IMPROVEMENT CONFERENCE

STATLER-HILTON INN
NORTH CAROLINA STATE UNIVERSITY AT RALEIGH
Raleigh, North Carolina
April 23 and 24, 1968

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Report of the

TWENTY-FIFTH SOUTHERN PASTURE AND FORAGE CROP IMPROVEMENT CONFERENCE[1/]

NORTH CAROLINA STATE UNIVERSITY AT RALEIGH
Raleigh, North Carolina
April 23 and 24, 1968

PROGRAM

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Tuesday - April 23, 1968 - Morning
Lincoln H. Taylor, Presiding

Opening Session

The twenty-fifth meeting of the Southern Pasture and Forage Crop Improvement Conference was opened by Conference Chairman Lincoln H. Taylor. Chairman Taylor introduced all present by State, government agency, and industry; he appointed a Nominations Committee of E. C. Holt (Chairman), T. H. Taylor, and H. D. Ellzey; and he appointed a Resolutions Committee of O. C. Ruelke (Chairman), W. C. Templeton, Jr., and C. H. Gordon. Dr. R. L. Lovvorn and Dr. George Hyatt, Jr., were introduced by Dr. W. W. Woodhouse as each presented his address to SPFCIC.

The Future of Forage Research - Roy L. Lovvorn, Director of Research, Agricultural Experiment Station, North Carolina State University.

It was my good fortune to have attended the first meetings of the Southern Pasture and Forage Crop Improvement Conference, the organizational meeting in Birmingham, Alabama, and the first subject-matter discussions at Tifton, Georgia, more than 25 years ago. Although I have not attended all of the sessions since that time, I have been able to maintain a more than casual interest in the work of this particular organization. On behalf of all of us from this University and this State we want you to be most welcome. We want you to enjoy our State, our climate, our campus, and most of all our staff. And of course we have hopes that the program and auxiliary tours will broaden your knowledge of forage crops and make you glad that you attended the 25th Annual Conference, and as a Station Director let me say that we hope you return to your research feeling that your investment in time and travel have been resources wisely used.

My local colleagues have suggested that I address myself for a few minutes to the future of forage research. Though having no self-evident crystal ball, I am honored to think with you on this subject.

About a billion acres of land area in the United States produce forage. About 700 million acres of forage producing land constitute 62 percent of the land area in farms, according to the U. S. Department of Agriculture 1967 agricultural statistics. In a talk at the American Society of Agronomy meetings last November, Dr. H. J. Hodgson stated that the estimated annual value of forage is about $8 billion. Forages provide more than half the feed units consumed by all livestock. Dairy cattle obtained two-thirds and beef cattle three-fourths of their feed from forage in 1965. In addition, there are many other uses of grasses and legumes, and so we are dealing with a most important commodity.

During 1966 a document was developed called "A National Program of Research for Agriculture". This is a report of a study sponsored jointly by the Association of State Universities and Land-Grant Colleges and the U. S. Department of Agriculture. Membership on the Committee consisted of a State agricultural experiment station director from each of the four regions of the country, a representative for marketing and one for home economics, and a similar group from the U. S. Department of Agriculture. The Task Force set these objectives for

the study:

1. Define the goals, purposes, and scope of agricultural and forestry research to serve the future needs and values of the American people at the local, national and international level.

2. Develop a research classification system, compatible with the information retrieval plans of the National Agricultural Library and the proposed Current Research Information System to facilitate more uniform and effective planning, development, evaluation, reporting, administration, and coordination of agricultural and forestry research by the Department, the State agricultural experiment stations, industry and other institutions.

3. Inventory quantitatively the allocation of USDA-SAES research activities by specific fields, and of industry and others by broad fields, in order to provide a basis for future allocations.

4. Project the research needed during the next decade to help people adjust to their changing economic and social environment and to improve their well being, and to meet the Nation's future requirements for agricultural and forestry products and resources.

5. Recommend relative emphasis for projected research for use of administrators and the Congress in making judgments concerning the distribution and level of support for different areas of research.

6. Consider the respective roles, responsibilities, and areas of cooperative effort among the Department, State agricultural experiment stations and others and recommend improved arrangements for planning, developing, financing and coordinating and administering the total agricultural research program.

According to this report there were 581 scientist man years engaged in forage, range and pasture research in the United States in 1966 - 390 scientist man years at the State experiment station level and 191 scientist man years within the U. S. Department of Agriculture. Their projected needs to 1972 were 677 scientist man years - 454 State and 223 Federal. By 1977, or 10 years from the time the projections were made, the needs were 578 scientist man years State employees and 287 scientist man years federal employees, or a total of 865 man years. This represents a growth from 581 to 865 scientist man years, or approximately 50 percent. I would assume this to be no sacred figure, but it does indicate that the joint committee felt some need for some substantial expansion in forage crop research in this country.

A second step in the further development of this long-range plan calls for in-depth studies in many areas. The Task Force on forage, range and pasture research was organized this past winter and is now in the process of making the study. Again, it is a joint undertaking by the States and the U.S. Department of Agriculture. The co-chairmen are Dr. A. A. Hanson (USDA) and your speaker. Other members of your Conference serving on the Task Force are Dr. W. B. Anthony,

Auburn University, and Dr. D. E. McCloud, University of Florida, Dr. H. J. Hodgson, CSRS, and Dr. C. H. Gordon, ARS, USDA. Of course I have no idea at this moment as to what the Task Force will come up with, but I am confident that the talent working on the assignment will produce some valuable guidelines for all interested in this subject in the years ahead.

Livestock production in the south has made great progress within the past 25 years, and this development is correlated with your achievements in research, but in the future the demands on you will be far greater. Now for the listing of a few areas where we need to do some hard thinking:

1. Biological Efficiency - We need still better forage crop varieties, both annual and perennial with higher yield potential and higher dry matter digestibility. Disease and insect resistance must also be maintained or increased. Our gains in genetic potentials for yield have not been spectacular in most forage crops with the exception of a few instances where asexual reproduction is possible, and even in these cases more potential for improvement exists. Biological efficiency probably involves numerous plant processes two of which are photosynthetic efficiency and the rate at which photosynthetic area is produced or expanded. There is, therefore, a critical need for devising methodology for rapid measurement of these characteristics so large numbers of plants can be evaluated.

2. Forage Quality - Because forages are chiefly of value to ruminant animals, proper evaluation must rest on measuring real or predicted animal performance. Burton and his associates have recently released a new bermudagrass that had a dry matter digestibility 12 percent higher and an animal performance 30 percent higher than Coastal bermudagrass. Of interest to me was their findings that the correlations between dry matter digestibility and conventional estimates of quality, such as percent dry matter, percent leaves, and percent crude fiber were too low to be of value in selection. This simply confirms my belief that we still have a lot to learn about forage quality.

3. Annual Crops vs. Perennials - When I was actively engaged in forage research the trend was toward perennials primarily because of the cost and uncertainty of getting dependable stands of annuals. Now seeding technology has changed and you have much more pressure for higher yields, especially from your more expensive lands. Perennials divert sizable portions of photosynthate to storage of reserves for regrowth and overwintering. Most annuals tolerate the hot summer weather better than perennials. Active growth in this period takes advantage of greater light intensity and duration, thus the justification for your greater attention to some of the more productive annuals.

4. Better Conservation Methods Needed - Production of high yields of higher quality forage as a result of using varieties with higher biological efficiency and improved management requires re-examination of present day harvesting techniques. For example: Are high management and production inputs compatible with the livestock management system based on grazing? At what level do further inputs become uneconomical in a grazing system? Have we properly defined the economic relationships between levels of production and management inputs and

methods of harvesting or utilization? Further, as the feed value per unit of dry matter is increased the dry matter losses of present day harvesting in processing methods become more intolerable and the demand to find improved methodology for the harvesting, processing and storage processes become greater.

5. Leaf Proteins - We have traditionally considered forages as livestock feed. Recent work at the Wisconsin station as well as at Rothamstead station gives good evidence for considering leaf proteins as human food.

We need more people and better trained people to do the things that we have been doing and to do some of the future needs that I have mentioned above. I think that we are also going to have to give some real serious consideration to our own individual efficiency in the years ahead. A few examples:

1. More Controlled Growing Conditions - This means more sophistication, more expensive instrumentation, but such procedures should enable us to do a more effective job in learning the "why" of forage behavior. We hope that the phytotron, to be officially dedicated at this University next month, will provide an environment for forage research not only for our local staff but for the region as well.

2. More Regional Planning - This could mean formal technical committees, and in some instances probably will, but I'm thinking more particularly about cooperation across state boundaries within homogeneous growing conditions. An example: Growing conditions in our mountain counties are much more like southwestern Virginia and eastern Tennessee than they are in 80 percent of our own state. The growing conditions of our Coastal Plain are much more like that of Virginia, South Carolina and the Georgia Coastal Plain than they are in the remainder of our state. We have not fully utilized this situation but we must. You could cite other opportunities in your locality I am sure.

3. Relationship Between Research, Development and Education - In a number of the states the Extension Service is redefining its role, and I look upon this as a real opportunity for the researcher to do a better job to develop new knowledge at a faster rate.

4. Regional Laboratories - We now have the mechanism through both USDA and the State experiment stations to concentrate our efforts on regional problems. The fantastic acceptance of Coastal bermudagrass is a classic example of how widespread the developments from research become. It seems to me there is a real potential here.

Yes, I am optimistic about the past quarter of a century, but I am much more so about the next 25 years. I just hope that all of us are thinking big enough in getting ourselves prepared for the years ahead, especially our graduate students. It is going to require/more concentration and it is going to require more cooperation cooperation between disciplines within your local setup and more cooperation between locations for the same disciplines.

Thank you.

Forage Extension in the next Ten Years - George Hyatt, Jr., Director, North Carolina Agricultural Extension Service, North Carolina State University

The best indication of what extension forage work will be like in North Carolina over the next 10 years is found in a long-range program prepared in 1966 by extension workers and other farm leaders. This program was named "Target 2" because it has as a major goal a gross agricultural income of $2 billion for North Carolina by the end of 1971.

Target 2 does not cover the full 10 years required of this paper, but it does offer firm suggestions as to what might be expected in the more immediate future. For example, Target 2 indicates the possibility of a 32 percent increase in beef cattle income and 18 percent increase in dairy income in North Carolina between 1965 and 1971. Such increases are tied closely to forage feeding programs. Forage feeding is seen as especially important for such things as grain-on-grass feeding, cow and calf operations, stocker programs, and the production of dairy heifers.

To understand the changes that are anticipated in forage extension, it is necessary to look first at current changes. Twenty years ago forage specialists were called to help plan grazing programs for poultry, hogs, dairy cattle, beef cattle, and sheep. Forage specialists no longer service poultrymen, and seldom do they service hog producers in North Carolina. Forage specialists still service dairymen, but dairying is changing rapidly. For example, North Carolina has only about half as many Grade A dairymen as the State had 10 years ago. Cow numbers have dropped by 33 percent over the decade, while milk production has stayed about the same. The dairyman now is a big business man, milking over 70 cows. One large dairy county in North Carolina averages over 80 cows per dairy. Sufficient grazing within reasonable walking distance is no longer feasible for a herd of this size.

Along with depending less on grazing, North Carolina dairymen are feeding more grain and silage, and less hay. They are feeding about one pound of grain to two pounds of milk and handling about two pounds of stored feed for each pound of milk. Little energy, then, is coming from grazing except for dry cows and young animals. In other words, in the modern dairy operation, the difference between the cost of grain and stored feed and the cost of grazing is more than compensated for by mechanization, standardization of feed quality, and economy of scale. In summary, the forage client in dairying has changing needs. He is becoming fewer in number and highly specialized.

Rapid change is also evident in beef production. Nationally, beef animals increased by 27 percent during the last 7 years. The use of harvested feedstuffs increased by only 14 percent, suggesting an increasingly important role for pasture in beef production. Beef numbers increased by about 50 percent in North Carolina during this period.

TABLE I

TOTAL HARVESTED FEEDSTUFFS[a]
Fed to Dairy-Beef-Sheep (Million Tons)

	1949-50	59-60	64-65
Concentrate	33.8	52.8	62.0
Hay	94.4	119.4	116.2
Silage	45.2	82.3	102.2
Other harvested forage	11.1	19.1	22.4
TOTAL	184.5	273.6	302.8
Pasture	———	121.9	131.3

[a]From U. S. Statistical Bulletin No. 379

With this trend toward greater use of pasture, it would appear that the ability to grow and utilize forages economically will in reality determine the progress of the beef cattle industry over the next 10 years. Similarly, the ability to grow silage economically and without loss of soil will materially influence the dairymen.

Changes in dairy and beef production, and especially the forage requirements of these two enterprises, have led to changes in the way that extension is seeking to serve these groups. One of the most noticeable changes in North Carolina has been the assigning of subject matter responsibility to each agent. Responsibility for forages has been assigned in most instances to the dairy or livestock agent. Most of these agents have been trained in the animal sciences, which means that the forage specialist has quite a task in carrying out his prime responsibility of training agents.

The pinpointing of agent responsibility has led to the development of more systematic training of agents. Training offered to forage agents in North Carolina is of four types. The first type is a week of formal, in-depth training, which is the equivalent of three semester hours of college work. Agents taking this training, for example, are required to work out a complete forage program for a specific farm in their county. The second type of training comes in the form of an annual requirement for agents to spend at least one day on a research station or farm. The third type of training is in the form of program review visits from specialists. A regular forage newsletter constitutes the fourth type of training given agents.

Most agents in North Carolina are still assigned to work in specific counties. There is a trend, however, toward employing agents on a multi-county basis.

If the pinpointing of agent responsibility and the providing of systematic training is one big change in forage extension in North Carolina, the second big change has been extension's involvement in "adaptive research." The planning that went into the development of Target 2 revealed many "practical type" problems for which extension workers needed more information. For example, many farmers have let their pastures "run out." That is, they started with ladino clover and fescue, but over time the clover has gone out. (This has resulted from a combination of many things). Farmers are not getting the calf gains that they need on the "run out"pastures, especially during the summer months. Extension workers have some ideas on what to do about the pastures. Frequent suggestions are to use a summer grazing crop, such as a millet or coastal bermuda, reestablish clover in parts of the pastures, and to use a high nitrogen fertilization program on the remaining pure fescue pastures. But, farmers come back with the question, "Does it pay?" To help answer this question, agronomy, animal science and farm management specialists started "on-the-farm testing" in 1967.

Of course, the answer to the "will it pay question" cannot be obtained in one or two years. Only one year of on-the-farm testing was sufficient, however, to cause two large farmers to begin a pasture renovation program. They established ladino clover in part of their pastures last fall, used millet for the summer months, and concentrated their nitrogen in large doses on small acreages of pure stands of fescue. These farmers have already begun to influence other farmers, as agents and specialists felt that they would.

On-the-farm testing has had a beneficial effect on extension workers themselves. It has encouraged a team approach to problems. It has shown that specialists from agronomy, animal science and farm management can and will work together. In addition, on-the-farm testing is proving the best way possible for specialists and agents to keep their feet on the ground. They are becoming keenly aware of farmer problems, and they are being challenged to find new answers and workable solutions to problems.

Another role that the forage specialist is playing at North Carolina State University is that of classroom teacher. N. C. State offers a two-year terminal course in agriculture. Students in most cases are young men who control or will control large acreages of land. Most of these plan to return to this land or go directly into closely allied occupations which service farmers. The demand for the practical-type instructor for these students is high, and forage specialists are uniquely qualified for this responsibility.

In summary, forage extension in the next 10 years appears to be going this way: At the county level forage responsibility and training are being given to specific agents, some of whom are working across county lines. At the State level, the forage specialist is becoming more of a formal trainer of agents, plus more of an adaptive researcher and classroom teacher.

Inheritance of Forage Quality - Robert C. Buckner, USDA, ARS, Lexington, Ky.

High forage quality was defined by Dr. C. B. Browning at this Conference in 1964 as one, first, with the greatest possible concentration of utilizable nutrients, and second, with these nutrients put in a forage "package" that is highly acceptable to the animal.

A tall fescue improvement program has been underway for a number of years in which an effort is being made to improve the forage quality of this species along lines described by Dr. Browning.

One method of breeding was to graze spaced plant nurseries of tall fescue and study the inbred progenies of the best grazed plants. Nurseries were repeatedly grazed during the summer and early fall seasons when tall fescue is least palatable to grazing animals. After three generations of selection the best grazed inbred lines were permitted to cross-pollinate to form "synthetic" varieties.

The Kenwell variety was developed and released July 31, 1965, as a result of this program. Results from a test repeatedly grazed for a 2-year period, showed that cattle consumed 44 percent more dry matter of Kenwell than of Ky. 31 when the animals were given free choice of both varieties. Kenwell has greater tolerance to certain leaf diseases and, consequently, maintains better color during dry periods and into winter than other commercially available varieties.

Kenwell and Ky. 31 varieties were compared for chemical constituents generally considered to be criteria of forage quality. Kenwell was equivalent to Ky. 31 in total sugars, crude protein, crude fiber and in vitro digestibility of dry matter. Thus, while some progress was made in improving the acceptability of the species, little progress was made in increasing the concentration of utilizable nutrients.

Intergeneric hybridization of both annual and perennial ryegrass with tall fescue is being employed in an effort to improve the palatability and nutritive value of tall fescue.

An annual ryegrass x tall fescue amphiploid hybrid, a (perennial ryegrass x tall fescue) x tall fescue backcross hybrid, Kenwell and Ky. 31 tall fescue were compared for digestibility, palatability, and chemical constituents thought to be related to nutritional quality of forages.

The amphiploid hybrid was higher in crude protein, total sugars, moisture, and in vitro digestibility and lower in silica and crude fiber than the backcross hybrid and tall fescue varieties. Palatability of the amphiploid was superior to the backcross hybrid and the fescue varieties.

All chemical consituents were closely associated and influenced digestibility and palatability. Silica was positively associated with crude fiber and negatively related to protein, sugar, moisture, and digestibility. The low silica content of the amphiploid hybrid possibly was inherited from the ryegrass parent. This indicated that a portion of the nutritional quality of the amphiploid was transmitted by the ryegrass parent.

The chemical constituents digestibility and palatability of the amphiploid hybrid suggests that it is possible through a breeding program to concentrate the utilizable nutrients into a forage package that is highly acceptable to the animal.

S_0, S_3, and S_4 lines of tall fescue selected in a breeding program for improved palatability to cattle were studied for protein, silica, and sugar content. Variability of the S_4 lines for the three chemical constituents indicated the possibility of developing varieties higher in protein and lower in silica or higher in sugar and lower in silica than the S_0 parents. However, because of the inverse relation between protein and sugar, apparently it would be difficult to isolate lines and develop varieties high in both protein and sugar.

What Information does the Forage Crop Scientist need from the Animal Scientist? - Glenn W. Burton, USDA, ARS, Tifton, Ga.

I have struck the word, "information," from the title of my assignment because we, as forage crop scientists, need much more than information from the animal scientist. He is the caretaker and spokesman for the consumer of our research. Without his help in designing and building new forages, we may continue to make horse-drawn carriages for which there is no market.

We forage crop scientists need the friendship and appreciation of the animal scientist. We need to know that he is interested in our forages. We need his time and talent to help us plan, carry out, interpret, and report our forage research. We need his influence with fellow animal scientists and livestock farmers. We need to be a part of the same team, where every member will be so anxious to please the consumer (the cow) that he will be willing to do more than his share and not care.

The animal scientist must help us define forage quality in terms other than pounds of livestock products per day. Both the animal and forage crop scientist must understand how such factors as age, quantity available, stocking rate, processing and type of animal affect forage-quality measurements. These scientists must control and characterize these variables in their joint research lest when published, it confuse rather than clarify our understanding.

More specifically, we need better techniques to measure forage quality. To meet the need, these techniques must be developed and evaluated by the animal and forage crop scientists working together. These techniques must measure the quality of a few grams of forage precisely enough to separate treatments or genotypes with small quality differences. These techniques must be inexpensive and adaptable to assembly-line processing. Finally, they must give repeatable measurements that correlate well with the performance of the ultimate forage consumer. The Tilley and Terry *in vitro* technique and R. S. Lowrey's nylon bag *in vivo* technique for measuring forage digestibility are examples of the kind of techniques we need to measure other forage-quality components, such as "intake." Basic research, directed toward an understanding of the nature of forage quality, will help to develop such techniques.

Finally, both animal and forage crop scientists must not forget that quality is not the only important characteristic that a forage must possess. Quantity, seasonal distribution, efficiency of production, cost and dependability may under many circumstances be more important than quality if man cannot have both. There is good reason to believe that in the humid Southeastern U.S. quality to a point can be improved without sacrificing quantity, dependability, etc. And it is toward this end that we must direct our efforts in the years that lie ahead.

What Information does the Animal Scientist need from the Forage Plant Scientist - John E. Moore, Florida Agricultural Experiment Station, Gainesville, Fla.

Animal scientists and forage plant scientists attending the Southern Pasture and Forage Crop Improvement Conference have much more in common than the names Animal and Plant might indicate. To orient this discussion toward more common ground, it seems in order to paraphrase the title of this paper, as follows: Information the Forage Utilization Scientist needs from the Forage Production Scientist. It is estimated that forages provide 75% of the total feed requirements of beef cattle and only a slightly smaller percentage for dairy cattle. The forage utilization scientist needs a vast and complex body of information from the forage production scientist; but rather than making a complete or comprehensive review of this information, this paper will discuss some general ideas and concepts that seem important as we look forward together in this area.

Let us begin with this basic premise: Ruminants can contribute to man's food supply without competing with man for food. This is not new and yet this concept should guide our thinking. Ruminants are able to contribute without competing by converting forages, by-products and non-protein nitrogen, such as urea, to meat and milk. At the present time in North America, it is economically feasible to feed ruminants rather large quantities of grain, such as corn and soybeans, for the production of meat and milk. We have heard much in recent years about the pressures that may cause a reevaluation and a readjustment of this situation. We must realize that, from a biological standpoint, the feeding of animals for purposes of food production is unavoidably inefficient.

Table 1 shows the efficiency of solar energy utilization for human food production by two systems (Raymond, 1967). A wheat yield of about 70 bushels per acre was assumed. This gave 4600 therms of energy as starch for human consumption which is 0.11% of the available solar radiation. Grass yielding 3.5 ton/acre fixed 3 times this amount of energy but when this grass energy was converted to edible meat, the amount of energy per acre as human food was only one-eighth of that from the wheat. Only about 4% of the grass energy was converted to meat. Raymond has shown, however, that the yield of beef energy per acre of grassland can be markedly improved.

Energy is a critical requirement of ruminants, but their most valuable contribution to human food is high quality protein. Table 2 shows the efficiency of protein conversion by various classes of animals (Preston, 1968). Dairy cattle for the production of milk are most efficient with 28% of the feed protein appearing in the milk. Poultry, both for the production of broilers

and eggs, are not far behind. The production of pork is somewhat less efficient, 17%. But beef cattle are far behind with only 8% of feed protein being converted to edible meat protein.

It seemed of interest, as shown in Table 3, to try to compare the protein yield of a plant such as soybeans to that from beef and milk. The yield of soybeans assumed here was about 70 bushels/acre, which may not be maximum, but is quite good. At 40% protein this gave 1600 lbs of edible protein per acre. The beef and milk yields per acre are quite high, a ton of beef and 32,000 lbs of milk, but these are not impossible. The beef and milk production assumes efficient utilization of digestible energy equivalent to that in one acre of corn silage yielding 10 tons of dry matter per acre. Of course, supplemental nitrogen would also be needed. Today, it seems hard to conceive of much higher animal production than this. Even so, the yields of animal protein are less than that of soybean protein.

But even with this inefficiency, the ruminant is capable of contributing to the world's food supply. Materials otherwise unsuitable for food can be converted to food through ruminant utilization. It may be that even the productive phases of the ruminant livestock industries will have to become increasingly dependent on forages as sources of energy. Even today, there are needs for forages that support more efficient production. But if forage utilization by producing ruminants is to be economical, it will be necessary to increase yields of forage per unit of land, increase nutritive value of the forage produced and increase the efficiency of conversion of forage nutrients to animal products. In order to progress in this direction, there are a number of questions the forage utilization scientist must ask the forage production scientist; for example: what forage to grow, how to grow this forage, when to grow it and where? After asking these questions, some other questions may immediately be expected in reply; for example: what kind of animal is going to be fed, how will the forage be used, when during the year will the forage be needed, and where will the animals be located?

Simple, straight-forward answers cannot be given to these questions, neither can the two sets of questions be answered independently. The forage needs of the ruminant livestock industries will always be dictated by the types of forage utilization systems being employed and there will always be various forage utilization systems for various phases of livestock production on various types of land. Forage production and utilization scientists must work together to evaluate the needs of these systems and develop forage programs which meet these needs.

As a first step in determining forage production needs, the energy requirements of a livestock production system may be estimated. For example, in Table 4 are two hypothetical beef production systems, both utilizing 1000 lb cows, both giving birth to 70 lb calves, and both weaning at 8 months. But note that in system A the weaning weight was 400 lbs as compared to 600 lbs for system B. Average daily gain from birth to weaning had to be 1.4 lbs and 2.2 lbs, respectively. Between 8 and 14 months in system A the steer calf was grown on grass or silage with limited grain feeding and reached 700 lbs gaining at an average of 1.7 lbs per day. After another 120 days in the feed lot the steer in system A reached 1000 lbs having gained 2.5 lbs/day. But under system B, the 600 lb calf went directly into the feed lot and reached 1000 lbs in 14 months after continuing to gain at 2.2 lbs

per day. These data are strictly hypothetical, but system A might reasonably be considered average while system B may be a rather high rate of production. Also shown in Table 4 is the hypothetical milk production of the two cows. These would seem to be reasonable levels of milk production but certainly they are not the lowest or the highest level. With these data the digestible energy requirements of both the cows and the calves can be calculated. In Table 5, the digestible energy needs of the cows and calves are shown both on a daily basis and as the total required for each of the various phases. The total needs of a phase were obtained by multiplying the daily needs by the number of days in each phase. In estimating the daily requirements, the National Research Council figures were used, except for the requirements of the lactating cows. Here the value used was 0.8 therms of digestible energy per pound of milk. Even if this assumption was in error, the relative differences should remain the same with high producing cow B requiring more digestible energy per year than cow A. Regarding the calves, the slower gaining calf required more digestible energy to reach 1000 lbs.

Table 6 shows the total input of digestible energy of the two systems with the input being partitioned between different phases. The maintenance requirements of the cows assumes no gain or loss in weight. The needs for production of milk and the newborn calf were calculated by subtracting maintenance from the total cow needs. The calf's needs from birth to weaning are those in addition to the energy supplied by the cow's milk. According to those calculations, milk supplied only about 25% of the total preweaning energy needs of the calf. The values for "steer to slaughter" are the post-weaning requirements. The total digestible energy input of the two systems, 14, 140 and 13,910 therms, are quite close, both about 14,000 therms. Note, however, the differences in the percentages of the total energy input that are partitioned between the cows and their offspring. Under system A the cow required about 44% of the digestible energy, while under system B almost 51%. This 51% is the same as a figure resulting from analysis of actual production data at the Texas Station (Joandet, et al. 1967). It is not necessary that these data (Table 6) be accurate or reproducable. They simply serve to illustrate the kinds of calculations and observations that can be made and should be made in order to make a thorough evaluation of a total forage production and utilization system. It is very important to look at the total system. Simply comparing the needs of the two steers from weaning to slaughter indicates that system A is grossly inefficient. However, if the cow needs and the supplemental needs of the calf are low as shown in this example, then the total system is not nearly as inefficient. Under system A a larger portion of the digestible energy might come from forages than under system B.

In Table 7 are several sources of digestible energy, the average digestible energy content of these sources, hypothetical yields in terms of tons of dry matter and the digestible energy yield per acre. The right-hand column (Table 7) was obtained by dividing the yield of digestible energy into the 14,000 therms of digestible energy required by the total beef production systems of Tables4, 5, and 6. Grass yielding 3 tons of dry matter would require 2.33 acres to provide the digestible energy needs of the system. Alfalfa yielding 7 tons would require only one acre; 200 bushel corn would require about 0.7 of an acre. Corn silage yielding 10 tons of dry matter per acre would require only 0.5 acres to yield this energy. This too, is information that should be considered

in looking at the total system.

Another kind of information is the amount of forage consumed. Figure 1 is a generalization showing the relationship between energy intake and efficiency of production. Efficiency is shown on the y axis as the energy balance, positive, negative or zero. A certain amount of digestible energy is required to maintain the animal as indicated by the letter M; if the animal consumes less than this amount it will be in negative balance and lose weight. It is only by feeding above maintenance that production is possible. No matter how much digestible energy is produced per acre, the amount of digestible energy consumed relative to maintenance controls the rate and efficiency of animal production. Table 8 shows the digestible energy intake of various forages (Wing, 1965). The intake of white clover, alfalfa and pearl millet was almost twice that of the maintenance requirement of the 1000 lb cow. The intake of pangolagrass, oats and alfalfa-clover in combination would hardly have been enough to meet the needs of the lactating cow. The intake of Sart Sargo just was at the maintenance level. It should be emphasized again that it is not enough to measure yield of dry matter per acre, or even the yield of digestible energy, but the level of intake must be considered.

There is a great need for imaginative research in the development of forage utilization systems. Table 9 shows a prime example of this kind of work (Jordan and Marten, 1968). Non-lactating ewes were stocked at two rates. At the light stocking rate they were allowed to graze continuously whereas at the higher stocking level, the ewes were restricted to small pens for a total of 80 hours per week. Carrying capacity in terms of grazing days per acre was increased 60% by the restricted grazing technique. Subsequent production by these ewes was not affected as indicated by the similar lambing percentages, similar birth weight of the lambs and similar 30-day weights. This would be a technique to consider in improving the efficiency of a forage production and utilization system. There are a number of other possibilities: (1) early weaning of calves; (2) the use of dry lot for cows; (3) if beef cows would produce twins, the cow maintenance cost would become a lower percentage of the total energy input; and (4) the use of ensiled complete feeds. There are undoubtedly many other possibilities. It will require years of such imaginative research before optimum forage utilization systems can be developed to fit each situation. During this period, there should be a cooperative effort toward the development of <u>total</u> systems of forage production <u>and</u> utilization that are optimum for each situation. It will be necessary to look at the type of land, evaluate its production potential and develop forage programs best suited for it. Critical evaluations of each phase of ruminant livestock production are also needed so that forage needs are better defined. Forage production scientists and forage utilization scientists should work toward these goals together.

Biological efficiency of land use should be a prime goal in forage production and utilization research. However, there are many considerations other than yields of digestible energy per acre or pounds of milk per acre. Investment in machinery, turnover of capital, taxes and other factors influencing profits must be considered. Land that will produce high quality forages which can be mechanically harvested, might produce grain with more profit. The economics of the total systems should be continually evaluated under the practical conditions of the moment. A practice which is not economical today, could

become economical tomorrow and forage systems of high biological efficiency should be ready to fill a need. And we must keep in mind that the ruminant system is primarily a protein producing system rather than an energy system and should be evaluated as such.

Many different kinds of information will be needed to support the development of optimum systems of forage production and utilization. Of great importance is information on forage nutritive value. This can be best appreciated by dividing it into three categories: voluntary intake, nutrient digestibility and efficiency of utilization of the absorbed nutrients.

Figure 2 illustrates the importance of voluntary intake (Preston, 1968). The data presented in Table 2 on protein conversion are plotted against feed intake in this figure. The intake values are the maximum expected by producing animals in terms of multiples of maintenance. The maximum intake by beef cattle is 2.1 times maintenance and their protein conversion is only 8%. Swine consuming 3 times and lactating dairy cows consuming 3.5 times their maintenance requirements are correspondingly more efficient in converting feed protein to human food protein. A serious limitation in beef cattle production is the relatively low intake level (Preston, 1968); sheep are similar to beef.

Figure 3 illustrates some factors controlling intake (Montgomery and Baumgardt, 1965). As energy digestibility increases, starting at about 40% there is an increase in both dry matter and energy intake. Energy intake here refers to that available to the animal as digestible energy. When the digestible energy needs of the animal are satisfied, dry matter intake will actually decline as energy digestibility increases. This inflection point is at about 67% energy digestibility for beef cattle (Preston, 1968). This value is expected in a ration consisting of 50% grain and 50% roughage. Forages, in general, fall between 40 and 67% digestibility of energy, below the inflection point. Although digestibility and intake are related, Reid (1961) has shown that intake is the more important factor in comparing the nutritive value of various forages. While energy digestibility (TDN) increased by only 36% when changing from lowest to highest quality forage, intake increased by 25%, or 6 times that of digestibility. There may be a greater opportunity to improve the performance of ruminants fed roughage by selecting forages for intake rather than for digestibility.

Forage nutritive value also involves the efficiency of utilization of forage nutrients. Figure 4 presents an example of one factor influencing this (Blaxter, 1962). This factor involves the role of the volatile fatty acids (VFA) that are produced during the rumen fermentation. The y axis shows efficiency in terms of the proportion of the metabolizable energy above the maintenance level which was stored as body tissue by fattening sheep. The x axis is the relative proportion of acetic acid in the rumen fluid of the sheep. As the level of acetic acid in the rumen fluid increased from 45 to 75%, the percentage of energy stored decreased from 60 to 20%. In animals fed forage the acetic acid molar percentage is generally above 60%. The volatile fatty acids in the rumen can be influenced by the type of diet; forages with higher levels of soluble carbohydrates may result in lower ruminal acetic acid and, thus, higher efficiency. There are also many animal variables affecting efficiency; the role of forage composition and its effects on the rumen

fermentation are simply mentioned as examples of the efficiency component of forage nutritive value.

If there is enough forage, it can be fed to ruminants and nutritive value measured in terms of intake, digestibility, efficiency and even animal performance. However, in forage breeding studies, and in small plot work, information on nutritive value must be obtained from analysis of small samples of forage. The techniques used must give an accurate estimate. There have been many excellent approaches to this problem. The acid detergent fiber and lignin analyses recently developed by Van Soest (1963) serve to predict digestibility as does in vitro dry matter digestibility (Tilley and Terry, 1963). Intake prediction is more illusive but the 12-hour in vitro digestion of forage cellulose has been significantly correlated with voluntary intake (Johnson et al., 1964). Artificial mastication (Troelsen and Bigsby, 1964) has also been used to predict intake as has the solubility of dry matter in various solvents (Donefer et al., 1963). No one technique will be adequate for all purposes, especially when more than one species of forage is being evaluated. Forage production and forage utilization scientists should work together to improve these techniques or select combinations of techniques that will be useful in plot and greenhouse studies. It would seem an important cooperative goal to develop nutritive evaluation techniques that could be applied just as routinely as yield determinations.

There is a definite need for cooperation in forage research, but there is also an equivalent need for specialization in the generation of the basic research information that will be needed for the development of forage production and utilization systems. Examples of these specializations in the area of forage utilization are (1) breeding and selection of animals for better forage utilization, (2) determining optimum management systems for various phases of livestock production, (3) developing balanced supplementation for ruminants fed forage and (4) improving the synthesis of protein from urea and biuret by rumen microorganisms. These are just a few examples.

By the same token, there are a great many areas of specialization within the field of forage production. There is a need for more detailed information on the interrelationships between the soil, plant and climate. Recommendations should be made with a ranch or farm as well as within a State as to the forage plant that would be most productive. More information is needed on the seasonal patterns of yield and nutritive value. The synergistic effects of two or more plants grown in combination should also be studied in detail. The storability of hay, haylage and silage crops may be a matter of increasing concern with intensive programs of forage utilization. Information to minimize harvesting losses is needed. The possibility of using multiple crop systems to maximize forage yield should be further explored. Optimum fertilization programs must be developed for all of these forages and forage systems.

Basic information is needed on the physical and chemical properties of forage which may influence the palatability and the selectivity of forage by animals. These are factors other than digestibility; perhaps there may be some chemical compounds causing a more or less desirable taste or smell. More information is needed on forage composition, especially the cell wall components as compared to the cellular contents (Van Soest, 1963). Lignin and silica inhibit cell wall digesting (Van Soest and Jones, 1963). Soluble

sugars and starches may improve the type of rumen fermentation and also improve the synthesis of rumen microbial protein from urea. These are only a few examples of the information needed from forage production scientists.

In summary, we must emphasize the need for looking at forage production and forage utilization in terms of the total system. This system is especially a protein producing system, with forages as energy sources for protein synthesis. We should be concerned with the evaluation and improvement of the biological efficiency of land use by ruminants. We are challenged by the problems involved in increasing yield, increasing nutritive value and increasing efficiency of utilization of forage nutrients. We can best meet these challenges through cooperative efforts, and through specialization on basic problems. Classical departmental divisions should not dictate where the necessary work is conducted. Progress in forage research is not as rapid as in grain research or poultry research; the variables are many and the interactions staggering. Only by thinking together in terms of the needs of the total forage production and utilization system, can our research have the orientation and direction necessary for progress.

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Table 1. EFFICIENCY OF CONVERSION OF SOLAR ENERGY TO HUMAN FOOD BY TWO SYSTEMS[1/]

Product	Energy	
	Therms/Acre	% of Solar
Wheat (2 T/A)	4,600[2/]	0.11
Grass (3½ T/A)	14,000	0.33
Meat (from grass)	570[2/]	0.014

[1/] Raymond, 1967.

[2/] for human consumption

Table 2. EFFICIENCY OF CONVERSION OF FEED PROTEIN TO PROTEIN FOR HUMAN CONSUMPTION[1/]

Animal	%
Dairy Cattle (milk)	28
Poultry (broiler)	26
Poultry (eggs)	23
Swine	17
Beef Cattle	8

[1/] Preston, 1968.

Table 3. THEORETICAL MAXIMUM PROTEIN YIELDS/ACRE AS SOYBEANS, BEEF AND MILK

Source	Yield/Acre (lbs)	
	Product	Edible Protein
Soybeans (dry)	4,000	1600
Beef (live)	2,000[1/]	300
Milk (fresh)	32,000[1/]	1100

[1/] Energy from corn silage, 10 tons DM/acre, plus supplemental nitrogen.

Table 4. TWO HYPOTHETICAL SYSTEMS OF BEEF PRODUCTION

Item	A	B
Cow weight, lbs:	1000	1000
Calf weight, lbs:		
Birth	70	70
Weaning (8 mos.)	400 (1.4)[1/]	600 (2.2)
420 days (14 mos.)	700 (1.7)	1000 (2.2)
540 days (18 mos.)	1000 (2.5)	-----
Milk production, lbs:		
Day 1 - 100	800 (8)	1400 (14)
Day 101- 240	700 (5)	1100 (8)
Total	1500	2500

[1/] Daily gain or milk production in parenthesis.

Table 5. DIGESTIBLE ENERGY REQUIREMENTS OF COWS AND CALVES IN TWO HYPOTHETICAL SYSTEMS OF BEEF PRODUCTION[1/]

Item	Digestible Energy (Therms)[2/]			
	Daily		Total	
	A	B	A	B
Cow:				
Wintering, Gestation (125 days)	14.8	14.8	1850	1850
Lactation: Day 1 - 100	19.7	24.5	1970	2450
Day 101 - 240	17.3	19.7	2420	2760
Total Cow Requirement	--	--	6240	7060
Calf:				
Birth - Wean (240 days)	7.8	12.5	1870	3000
Day 241-420 (180 days)	16.8	25.7	3020	4630
Day 421-540 (120 days)	29.0	--	3480	--
Total Calf Requirement	--	--	8370	7630

1/ See Table 4 for descriptions of Systems A and B.

2/ One Therm = 1000 Kcal

Table 6. DIGESTIBLE ENERGY INPUT OF TWO HYPOTHETICAL SYSTEMS OF BEEF PRODUCTION[1/]

Item	Digestible Energy			
	Total Therms		% of Total	
	A	B	A	B
Maintain Cow[2/]	4850	4850	34.3	34.9
Production (milk + calf)[3/]	1390	2210	9.8	15.9
Total for Cow	6240	7060	44.1	50.8
Calf to Weaning[4/]	1400	2220	9.9	16.0
Total to Weaning	7640	9280	54.0	66.8
Steer to Slaughter	6500	4630	46.0	33.2
Total System	14,140	13,910	100.0	100.0

1/ See Table 4 for descriptions of Systems A and B.

2/ 365 days

3/ Difference between total cow requirement (Table 5) and yearly maintenance requirement.

4/ Difference between total calf requirement (Table 5) and estimated amount of DE supplied by cows milk.

Table 7. SEVERAL DIGESTIBLE ENERGY SOURCES

Source	DE/lb DM	Yield/Acre		Acres per 14,000 Th.
		DM	DE	
	(Therms)	(Tons)	(Therms)	
Grass	1.0	3	6,000	2.33
Alfalfa	1.0	7	14,000	1.00
Corn grain	1.6	6	19,200	0.73
Corn silage	1.4	10	28,000	0.50

Table 8. INTAKE OF DIGESTIBLE ENERGY BY CATTLE CONSUMING DIFFERENT FORAGES[1/]

Forage[2/]	Th/day[3/]
White clover (S-1)	25.8
Alfalfa (Hairy peruvian)	24.2
Pearlmillet (Gahi)	24.0
Pangolagrass	18.8
Oats (Seminole)	17.8
Alfalfa + Clover	17.6
Sart Sargo	13.0
(DE requirement to maintain 1000 lb. cow	13.3)

1/ Wing, 1965.

2/ fed as greenchop

3/ Therms of digestible energy consumed per day by mature steers, heifers or non-lactating cows, adjusted to 1000 lb. body weight.

Table 9. EFFECTS OF RESTRICTED GRAZING IN SHEEP ON CARRYING CAPACITY AND EWE PRODUCTIVITY[1/]

Item	Grazing Time/Week	
	186 hr.	88 hr.
Grazing period, days	84	84
Maximum ewes/acre	15.9	27.2
Grazing days/acre	850	1361 (+60%)
Lambing %	152.0	154.5
Lamb weight, lbs.:		
Birth	11.1	11.0
30 days	25.6	26.3

1/ Jordan and Marten, 1968.

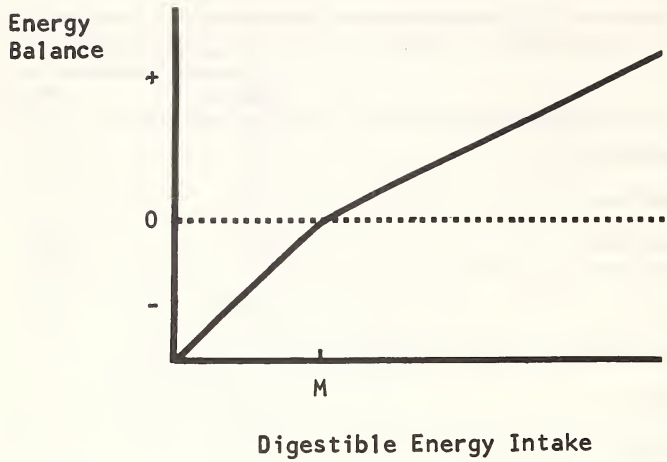

Figure 1. The effect of digestible energy intake on energy balance (M = maintenance requirement).

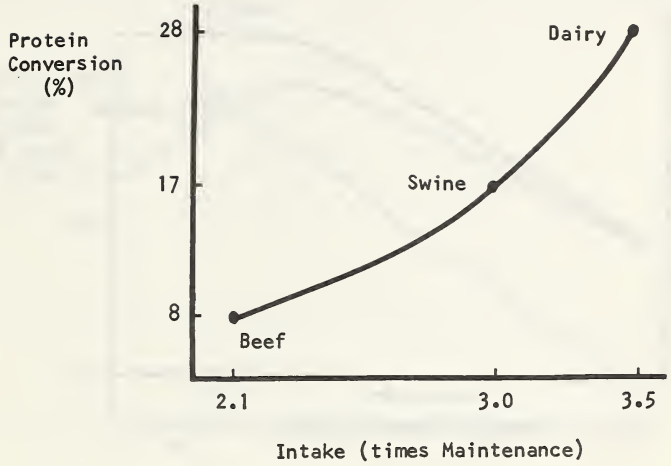

Figure 2. Relationship between the maximum feed intake expected in three species of livestock and their efficiency of protein conversion (Preston, 1968).

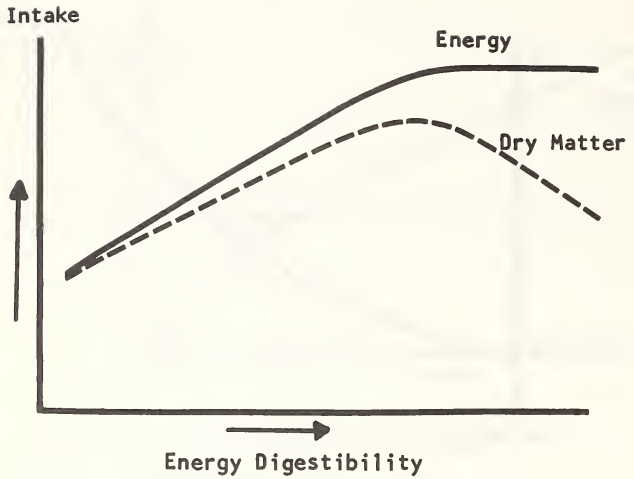

Figure 3. Hypothetical relationships between the energy digestibility of a ration and the intake of dry matter and digestible energy (Montgomery and Baumgardt, 1965).

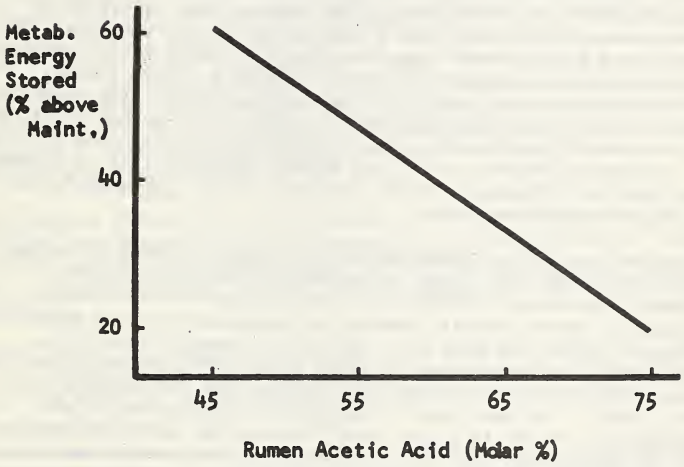

Figure 4. Relationship between the molar proportion of acetic acid in rumen fluid and the efficiency of utilization of metabolizable energy (Blaxter, 1962).

Collaborative In Vivo and In Vitro Studies NC-64 - Jesse M. Scholl, Wisconsin Agricultural Experiment Station, Madison, Wis.

Considerable interest has developed over the past decade in the development and use of methods for evaluating forage quality. This interest has resulted in a number of publications reporting investigations comparing in vivo, in vitro and chemical methods that may be used for this purpose.

Beginning in 1959, a forage evaluation group has been meeting informally to discuss experimental results and the possibility of standardization of in vitro techniques among laboratories. During the course of these meetings several cooperative projects were planned and subsequently undertaken.

Results of one of these collaborative in vivo studies were published by Donefer (1966) reporting trials involving 15 participating laboratories. Dehydrated alfalfa from a common source was distributed to cooperating laboratories and fed to sheep and cattle in digestibility and voluntary intake studies. Measures of the variability associated with the chemical and in vivo data were evaluated for both within- and among-laboratory sources. The author concluded that the "major sources of experimental error in this study were found to be due to differences in chemical composition of the forage caused by lack of uniformity of test material, and to differences in the chemical and in vivo methods as used in the collaborating laboratories."

A preliminary study involving dehydrated alfalfa meal purchased by Purdue University in 1960 and used in in vitro fermentation studies by several laboratories showed considerable variability between laboratories in mean cellulose digestibility after specific lengths of fermentation. The variance associated within and among runs also differed greatly among laboratories. This work was followed by collaborative in vitro rumen fermentation studies with forage substrates conducted by 17 cooperating laboratories with results published by Barnes (1967). The magnitude of in vitro digestion, and of the variability associated with the in vitro rumen fermentation technique was investigated. The in vitro digestibility of cellulose and dry matter was obtained for three forage substrates, analyzed in three runs with duplicate determinations with length of incubation set at 6-, 12-, 24- and 48- hours. Alfalfa meal from Purdue, and alfalfa hay and bromegrass hay from MacDonald College were used.

Barnes concluded from this cooperative work that "considerable variation occurred in the techniques employed by the different laboratories. The mean in vitro digestibility for individual laboratories after a 24-hour fermentation period, ranged from 40.0% to 63.9% for cellulose and from 38.7% to 53.3% for dry matter. The interactions of laboratories with the length of fermentation time and with substrates were significant. Digestibility increased as the length of incubation increased, but at different rates for grass and legume substrates.

The development of a standard in vitro procedure appears to be necessary if a more direct comparison of in vitro results among laboratories is desirable. The variability among laboratories was greater than among runs within laboratories, which was greater than between duplicate determinations within runs. The precision of the in vitro methods, as reflected in the variance estimates associated with runs and determinations within runs did not differ greatly among laboratories, except for individual cases. The precision was greatest at the longer fermentation periods."

Forage evaluation research personnel are convinced that the development and testing of laboratory methods for the evaluation of forage quality must be based upon forage samples with known in vivo data. The usefulness of laboratory techniques depends upon the validity of these in vivo results.

Recognizing the need for standardized in vivo methods for digestibility, and particularly voluntary intake, Barnes (1968) conducted a second collaborative in vivo study. Results were reported at the Symposium on Coordinated Research on Forage Evaluation, 58th Annual Meeting of the American Society of Animal Science, New Brunswick, N. J. This study, (published in the March 1968 issue of the Journal of Animal Science) was designed with a three-fold purpose: (1) to develop and test an in vivo method which will give reliable and efficient estimates of digestibility and voluntary intake, (2) to study the variability within and among stations associated with digestibility and voluntary intake of forages and (3) to procure forage samples with accurate and precise in vivo measurements for use in the development of laboratory methods for estimating forage quality. Personnel from six Agricultural Experiment Stations in the North Central region cooperated in the study.

First growth alfalfa hay, from Nebraska, harvested either at one-fourth bloom or full bloom, was shared with the cooperating stations and fed to lambs procured from a common source. All stations followed the same in vivo procedure which included a 12-day preliminary period and ad libitum and restricted intake phases of 9 days each.

Barnes summarized results as follows, "The mean dry matter digestibility (DMD) during the restricted phase for the two hays ranged from 59.9 to 61.9% among stations. The mean dry matter intake (DMI) for the two hays ranged from 79.1 to 88.3 grams per wt. $_{Kg}$.75.
The standard deviations among sheep within stations were 2.19 for DMD and 6.39 for DMI. The variation in the determination of chemical constituents and their digestibility emphasized the importance of sampling and preparation of forages for analysis. (All forage, fecal and ort samples were analyzed for cellulose at one station, and for approximate analyses at another station.) The magnitude of variability among sheep within stations was greater than among stations for dry matter digestibility measured during the restricted intake phase. The same was true for voluntary intake. Further in vivo trials of this nature would contribute toward the procurement of forage samples with accurate measures of in vivo digestibility and intake for use in laboratory studies."

Present plans, developed by Barnes, and others cooperating with him, call for an in vivo collaborative study among four stations (Ohio, Indiana, Illinois and Dixon Springs, Illinois) using high and low quality tall fescue grown and processed at the Dixon Springs Experiment Station in southern Illinois. The "standardized" in vivo procedure for comparison of digestibility and intake of hay among these stations is being reviewed by those who will use it. Agreement should be reached by now, and others wishing to see the procedure may write to J. C. Hinds, Chairman of NC-64. His address is: Dept. of Animal Science, University of Illinois.

Another proposed study will involve the use of a "standard" procedure which all laboratories will agree to follow prior to participating in the study. Three in vitro runs, using 12 forage substrates with duplicate determinations within each run, will be completed. The forages are selected on the basis of samples with

sufficient quantity available for distribution as well as a range in quality in terms of digestibility. Most of the samples have dry matter intake values which are available. The proposed in vitro procedure is a modified Tilley-Terry method for determining digestible dry matter. This procedure is now being reviewed by an NC-64 subcommittee composed of R. F. Barnes, Purdue University, E. E. Bartley, Kansas State University, and J. W. Thomas, Michigan State University. A copy of the procedure may be obtained from them, along with the experimental design to be followed.

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Concepts and Requirements for Cooperative Evaluations - C. F. Lewis and Smith Worley, Jr., USDA, ARS, Beltsville, Md., and Knoxville, Tenn., respectively.

Your program chairman, Dr. H. A. Fribourg, is located at the University of Tennessee at Knoxville, and this is also the site of the U.S. Cotton Fiber and Spinning Laboratories. These laboratories are an essential part of the cooperative evaluation of the characteristics of cotton varieties and experimental strains. Dr. Fribourg's knowledge of their work and his close association with Dr. Smith Worley, Jr., caused him to invite us to discuss with you the essential features of the regional cotton variety tests. We hope that our experience in cooperative evaluations will benefit members of the Southern Pasture and Forage Crop Improvement Conference.

The Regional Cotton Variety Tests were begun in 1960 and are currently in the 9th consecutive year of operations. This testing program is a system of cooperative evaluations of the agronomic, fiber quality, and spinning characteristics of cotton involving Federal and State agencies as well as commercial cotton breeding firms. We propose to discuss why and how the program was originated; how the program operates; and some appraisal of its usefulness and limitations.

The program originated from deliberations of the Joint Cotton Breeding Policy Committee. This is an ad hoc committee composed of three State experiment station directors, three executives from commercial cottonseed companies, two U.S. Department of Agriculture administrators, and a permanent secretary from the National Cotton Council. These leaders realized that many cotton variety tests were being conducted in the 1950's, but with very little coordination among the States. A National Cotton Variety Testing Committee was appointed to work out the details of a program of coordinated variety testing. Before this committee met to decide what to do, a survey was made of what was already being done. Reports from 14 States and 4 private seed companies for the 1958 season were studied for location of tests, names of varieties tested, characters measured, units of measure, and any other pertinent information. The findings indicated that each State was doing a good job of testing and reporting. It was obvious that State lines did not outline logical zoning arrangements for cotton variety testing. Discrepancies in entries and units of measure in the State programs made combined analysis of data between states impossible. Examination of the total program indicated that a coordinated program was possible without any additional amount of work. Agreement on a common set of traits, use of the same units of measure, and the testing of the same varieties within each region were necessary for maximum usefulness of the data. Further study revealed that individual cooperators would have to make only minor adjustments in test procedures.

The National Cotton Variety Testing Committee met in 1959 and worked out the details of the Regional Cotton Variety Testing Program. The essential features of the current program are as follows:

1. The United States cotton production area is divided into 6 test regions for Upland cotton; Eastern, Delta, Central, Plains, Western, and San Joaquin Valley. One region tests extra-long staple Pima cotton, and another regional plan accommodates strains and varieties with exceptionally good quality. A second high quality evaluation program has been organized for the High Plains region.

2. Official test sites are designated for each region and are selected from among those sites where testing is already being conducted by the State experiment stations.

3. In the regular Upland tests, four varieties are designated national standard entries and grown in all locations in each region for a period of 3 years.

4. Regional standard entries are common to all tests within a region. This list is subjected to modification each year. Regional entries may be either commercial varieties or experimental entries that are good prospects for realease. A single seed source is used for each national and regional entry to minimize differences in seed quality.

5. Optional entries of local interest may be included but are not reported in the regional results.

6. Details of design, number of replications, plot size, cultural practices, and sampling methods are left to the discretion of the participating stations. All tests, while not rigidly standardized, are supervised by research personnel using sound experimental designs and procedures.

7. Five agronomic characters are uniformily reported by all stations. These field data are reported to Beltsville on a form designed for compatibility with the computer program. Data cards are punched directly from this form thereby eliminating the necessity of recopying the data.

8. Lint samples are sent to the U. S. Cotton Fiber and Spinning Laboratories, Knoxville, Tenn., where 13 fiber and spinning characters are measured. Knoxville data are now received in Beltsville on punched cards ready for the computer.

9. The data are analyzed and printed out in a form adaptable for publication. This eliminates typing and proof reading.

10. Data are published in the ARS 34 series[1/] annually and distributed in bulk to participating States for internal distribution. We honor requests for the bulletin if addressed to Beltsville. Many requests come from textile manufacturers outside the cotton producing States.

1/ Most recent issue is "ARS 34-96, December 1967, Results of 1966 Regional Cotton Variety Tests by Cooperating Agricultural Experiment Stations."

Discussion

Cotton research people feel that the Regional Cotton Variety Testing Program has been successful. In our opinion, several things contributed to that success.

1. The administration of Federal and State agencies and commercial companies supported and encouraged the project.

2. Variety tests were already being conducted by State experiment stations. An uncoordinated existing program could be slightly modified to make a coordinated program. No new personnel had to be hired; no new tests were needed; no additional money had to be appropriated. Participation is voluntary, and requirements for complying with the program are left as flexible as possible.

3. Instruments had already been invented to measure the fiber characteristics that were significantly correlated with the performance of cotton in textile mills. These instruments had been assembled in the U.S. Cotton Fiber and Spinning Laboratories and other laboratories; however, many States did not have access to a laboratory. Reports had little information on fiber quality and none had a measure of spinning performance. At the Knoxville laboratories. automatic data recording, automatic data processing, assembly line techniques, and an experienced staff made the testing of large numbers of samples feasible and economical. Quality control procedures assured test precision and level. When the cooperative program was organized, the increased efficiency of the laboratories made it possible for the USDA to serve as the central laboratory for

making fiber and spinning determinations on samples drawn from the regional cotton variety tests.

4. Computing facilities were available in Biometrical Services of the Agricultural Research Service which made possible the analysis and publication of masses of data.

5. Local experiment station personnel thought that the program was sound and gave it their cooperation. It is important that local stations understand how they fit into the total program, and that their cooperation be recognized and acknowledged.

In short, the ingredients of the program existed; it was only necessary to bring the separate parts together into a total coordinated program.

What have been some of the benefits?

1. The bulletin is a handy reference. It is much more readily available and usable than are separate reports each in a different format. All data are at a comparable level and significant differences are indicated.

2. It is well known statistically, that there is efficiency in combining tests data over locations and years. This allows means to be based on a large number of observations, and thus makes them more reliable.

3. The data are drawn from an experimental design which allows the separate influence of variety, location and seasons, and their various interaction components to be calculated.

4. The regional testing concept and procedures have been adopted as a model in several cotton breeding programs by breeders evaluating their own advanced strain tests.

5. The trustworthiness of the conclusions that can be drawn has made the data very valuable: (1) for breeders wanting to know the relative performance of cotton varieties; (2) for textile mills wanting to know the inherent characteristics of varieties in the different production areas; and (3) for experiment station and extension personnel recommending varieties to producers.

6. The accumulation of data over a period of years on data cards presents an opportunity for research beyond the analysis of variance and the tabulation of means. We are authorized to loan decks of cards to universities with statistical departments and graduate students looking for problems. Dr. A. A. Abou-El-Fittough of North Carolina State University completed his dissertation on genotype by environmental interactions in cotton and their implications in zoning. Dr. Smith Worley, Jr. is working with graduate students at the University of Tennessee on the interrelations of the components of yield, the components of quality, and the yield-quality associations. Yield and quality models are now being formulated, tested, and compared for inferences such as effects of ecological areas, seasons, and plant breeding procedures.

So far we have not found a uniform way to measure disease resistance and earliness of maturity. Diseases vary considerably in their attack from location to location and season to season; and the severity is often expressed in some arbitrary scoring system which is not comparable from investigator to investigator. Practical measures of earliness of maturity are not comparable among locations. We get indications of disease resistance and maturity, but have not collected analyzable data on these traits.

The system of regional cotton variety tests works reasonably well for this crop. What elements of that system which would be adaptable in other crops would depend upon their particular problems. In this era of assembly line techniques and automatic data processing, masses of data drawn from sound experimental designs can lead to valid comparisons of the measurable agronomic and quality characteristics of crops.

A Summary of Discusion - Moderator, Gerald E. Carlson, USDA, ARS, Beltsville, Md.

Forage quality is a function of both animal and plant factors. Any method for measuring quality must then consider these interacting factors if it is to be accurate. Animals vary in efficiency of utilization of forages; a case in point is the water buffalo which apparently has a more efficient digestive system than other classes of livestock. Animals can probably be selected for more efficient conversion of forages to animal products.

Similarly, plants are extremely variable in the factors which affect quality. Management, genotype, and physical form are variables which can be altered to improve quality. Environment also affects quality but is subject to very limited modification. Selecting plants for improved digestibility requires techniques which are rapid, simple, precise, inexpensive, and correlated with animal performance. Chemical analysis, *in vitro* fermentation and *in vivo* nylon-bag are techniques which are being used but which require further refinement and standardization. Most probably there is not a single procedure which can be used to estimate digestibility of all forages. But, adapting a standard procedure and testing at a central location would build a body of data from which changes and improvement could be made with a high degree of direction. The goal is to *improve* forage quality and hence animal performance, not simply to *measure* it.

General Business Meeting - Chairman L. H. Taylor, Presiding

The general business meeting of SPFCIC was called to order at 4:45 P.M., April 23, 1968, by Chairman L. H. Taylor.

Chairman Taylor read the letter he received from Mr. Arturo Roque, Director, Agricultural Experiment Station, University of Puerto Rico, Rio Piedras, dated March 25, 1968, inviting the SPFCIC to hold its 1969 meeting in Puerto Rico. Chairman Taylor reported that the Executive Committee considered the invitation and, despite possible limitations in travel, recommended acceptance of the invitation.

The motion to accept the invitation from Director Roque to hold the 1969 SPFCIC in Puerto Rico passed unanimously.

Chairman Taylor announced that a Committee will work toward schedule, transportation methods, and program for 1969 meetings, and welcomes suggestions from the membership on the 1969 meeting.

A motion made by Riewe, seconded by Burton, and passed unanimously, was as follows:

> "That the Southern Pasture and Forage Crop Improvement Conference instruct its Secretary to write the presidents of the Southern Sections of the American Society of Agronomy, the Animal Science Society of America, and the American Dairy Science Society that this Conference strongly supports one or more joint sessions of these three societies at the annual meeting of the Southern Agricultural Workers. The Southern Pasture and Forage Crop Improvement Conference further urges that, insofar as possible, the program be made up of volunteer papers."

A motion was made by Schank, was seconded, and was passed unanimously, that the Executive Committee appoint a committee to pursue the problem of quality evaluation of forages.

Chairman Taylor introduced the 1968 Executive Committee. E. C. Holt presented the Nominations Committee nomination of D. H. Timothy as SPFCIC Chairman Elect-Elect; the motion to close nominations and to instruct the Secretary to cast an unanimous ballot for Dr. Timothy was passed unanimously. The Chairmen (or their designated representative) and Past Chairmen of Interest Groups (1 vote per group) and officers of SPFCIC, all constituting the Executive Committee of SPFCIC, for the forthcoming year are as follows:

Group	Admin. Adv.	Past Chairmen	Current and Program Chairmen
S-45	C. E. Barnhart	C. H. Gordon	H. D. Ellzey
SFBG	O. B. Garrison	C. R. Owen	R. C. Buckner
SFPEWG	R. L. Lovvorn	D. S. Chamblee	E. G. Beinhart, Jr.

SPFCIC	Past-Past Chairman	H. A. Fribourg
	Past and Program Chairman	L. H. Taylor
	Chairman	M. E. Riewe
	Chairman Elect	C. L. Mondart, Jr.
	Chairman Elect-Elect	D. H. Timothy
	Permanent Secretary	R. C. Leffel

The meeting was adjourned at 5:00 P.M.

Business Conducted during Banquet Meeting - Report of the Resolutions Committee - Resolved:

That the membership of the 25th Southern Pasture and Forage Crop Improvement Conference express their appreciation to the Administration and Staff of North Carolina State University for the fine hospitality provided for the Raleigh Conference and associated work-group meetings. The superb facilities, well planned arrangements and instructive field tours contributed substantially to the success of the meetings.

North Carolina State University is to be commended for its awareness of agricultural problems, and its vision and leadership in attacking and solving the problems related to Forage Crop Improvement and Utilization.

Appreciation is expressed to the Local Arrangements Committee, D. S. Chamblee, Chairman; C. T. Blake, J. C. Burns, T. H. Busbice, J. D. Washburn, J. G. Clapp, Jr., W. A. Cope, S. H. Dobson, D. H. Timothy, W. W. Woodhouse, Jr., and Mrs. David Timothy, Chairman of the Ladies Committee. Special appreciation is also expressed to Chairman Lincoln H. Taylor and to Secretary R. C. Leffel, for their effective leadership during the past year, and to Henry A. Fribourg who has served as program chairman.

We move that this resolution be adopted and recorded in the minutes and that a copy of this resolution and letters of appreciation be sent to Dr. Roy L. Lovvorn, Director of Research; Dr. George Hyatt, Jr., Director of Extension; Dr. Paul Harvey, Head, Department of Crop Science; Dr. R. J. McCracken, Head Depart of Soil Science; Dr. I. D. Forterfield, Head, Department of Animal Science; and Dr. Douglas S. Chamblee, Chairman of Local Arrangements.

Respectively submitted,

O. Charles Ruelke, Chairman
William C. Templeton
Chester H. Gordon

The above motion passed unanimously by popular acclaim. M. E. Riewe assumed the chair and adjourned the Banquet meeting at 8:50 P.M.

Executive Committee Meeting - Chairman L. H. Taylor, Presiding

The Executive Committee Meeting of SPFCIC was called to order at 8:00 P.M., Monday, April 22, 1968, by Chairman L. H. Taylor. Present were H. A. Fribourg, C. L. Mondart, Jr., E. G. Beinhart, Jr., R. C. Buckner, C. R. Owen, D. S. Chamblee, H. D. Ellzey, W. B. Anthony, M. E. Riewe, S. C. Schank, C. H. Gordon, and R. C. Leffel.

Taylor announced that Mr. Arturo Roque, Director, Agricultural Experiment Station, University of Puerto Rico, Mayaguez Campus, Rio Piedras, Puerto Rico 00928, has invited SPFCIC to hold their 1969 meeting in Puerto Rico, via letter to L. H. Taylor, dated March 25, 1968. Also, preliminary contact has been made with Oklahoma concerning a site for a future meeting.

A discussion followed on advisability of Puerto Rico as a meeting site. Plane fare, round trip, Miami to Puerto Rico was cited as approximately $94. Puerto Rico has participated in SPFCIC for the past 20 years; through the years the Conference has convened in each of the Southern States but not in Puerto Rico. Concern was expressed on reduction of attendance because of possible limitations on travel and on approvals via Experiment Station Directors. It was a consensus that we should recommend to the Conference acceptance of the invitation from Puerto Rico for the 1969 meeting. A committee to study and advise on Puerto Rico as a meeting site was appointed by Chairman Taylor, as follows: Schank, Anthony, Fribourg, and Puerto Rico participants.

Chairman Taylor appointed the Nominations Committee of E. C. Holt, Chairman; T. H. Taylor, and H. D. Ellzey, and the Resolutions Committee of O. C. Ruelke, Chairman, W. C. Templeton, Jr., and C. H. Gordon.

Riewe suggested that SPFCIC support joint sessions of Southern Sections of American Society of Agronomy, Animal Science Society of America, and American Dairy Science Society at annual meetings of Southern Agricultural Workers. Discussion followed and Riewe was asked to present his suggestion as a motion in the next day's general business meeting of SPFCIC.

Taylor presented John Shoulder's suggestion of a joint meeting with Turf workers; the majority of Executive Council thought same not advisable. Extension workers' role at SPFCIC was discussed, and Leffel was asked to review mailing list to assure that Extension and all other interested Departments and personnel were included.

The next Executive Committee meeting was scheduled immediately after the banquet. The meeting was adjourned at 8:55 P.M.

Executive Committee Meeting - Chairman L. H. Taylor, Presiding

The Executive Committee Meeting of SPFCIC was called to order immediately after the banquet on Tuesday, April 23, 1968, at 9:00 P.M., by Chairman L. H. Taylor, with M. E. Riewe, C. H. Gordon, W. B. Anthony, E. G. Beinhart, Jr., C. L. Mondart, Jr., C. R. Owen, J. E. Muriente, H. D. Ellzey, D. H. Timothy, H. A. Fribourg, D. S. Chamblee, K. M. Barth, and R. C. Leffel in attendance.

A discussion on transportation expenses to Puerto Rico ensued: air, round trip, from Miami was quoted as $92.50, tax free; air charter is approximately $80; boat 2 1/2 days each way is $325. Henry Fribourg was asked to investigate possible charter plane use, with several stops enroute in the Southeast and so advise 1969 SPFCIC Chairman Riewe. The consensus was that there is little interest in charter unless saving is more than 30 percent.

Jose E. Muriente will contact Puerto Rico personnel and advise the Executive Council of the desirable date for 1969 meeting as soon as possible. Tentatively dates between April 25 and May 20, or after June 10 and not in conflict with Dairy Science meetings, were suggested. L. H. Taylor will write Dr. J. V. Fortuno and advise him of acceptance of Puerto Rico's invitation for 1969 SPFCIC. Leffel is to write Director Roque, accepting Puerto Rico's invitation for 1969 SPFCIC and requesting provision for the three interest groups and the local Arrangements Committee.

The SPFCIC program for 1969 was discussed. Riewe suggested Tropical Grassland Agriculture as a topic. Muriente indicated that meeting sites within Puerto Rico will be designated by the Host Institution. The need to get information to the membership on 1969 plans as soon as possible was emphasized - also the membership is to indicate tentatively plans to attend as soon as possible.

Fribourg emphasized the desirability for deadlines in program planning. Riewe thinks speakers for the "Tropical Grassland Agriculture" topic available from Puerto Rico and from Southeastern States.

A tentative program was agreed upon, as follows:

1st day, Monday - S-45 and Work Group Sessions
2nd day, Tuesday - A.M. - Puerto Rico Administration and Research
P.M. - Tropical Agriculture by Specialists
3rd day, Wednesday - All-day Tour
4th & 5th days - A Tour of 2 days or so of Island Agriculture suggested but Host Institution will decide and inform us of such plans.

The Executive Committee discussed the motion passed in the general business session of SPFCIC, that the Executive Committee appoint a committee to pursue the problem of quality evaluation of forages. This committee was appointed to consist of J. E. Moore (Chairman), G. W. Burton, R. C. Buckner, H. D. Ellzey, C. S. Hoveland, and J. C. Burns, and is charged with the responsibility to propose an organizational vehicle to do forage quality tests on a regional basis for research purposes, at the next meeting of SPFCIC. Chairman Riewe will instruct the committee via letter.

It was noted that Professor R. H. Lush of the University of Tennessee deceased within the past year, and the Secretary was instructed to send Mrs. Lush a letter of condolence from the Executive Council of SPFCIC.

The meeting was adjourned at 10:50 P.M.

REGISTRATION LIST - 1968

Name	State	Address
Anthony, W. Brady	Alabama	Auburn University
Donnelly, E. D.	"	" "
Evans, E. M.	"	" "
Hoveland, Carl	"	" "
King, Cooper	"	" "
Rollins, Gilbert	"	" "
Mays, David A.	"	Muscle Shoals
Rice, Harold B.	Arkansas	North Little Rock
Ellis, George	Florida	Gainesville
Hayes, B. W.	"	Belle Glade
Hodges, Elver M.	"	Wauchala
Kretschmer, Albert M.	"	Ft. Pierce
Moore, John E.	"	Gainesville
McCaleb, J. E.	"	Ona
McCloud, Darell E.	"	Gainesville
Nelson, Billy	"	"
Ruelke, O. Charles	"	"
Schank, S. C.	"	"
Brown, R. H.	Georgia	Athens
Burns, Robert E.	"	Griffin
Burton, Glenn W.	"	Tifton
Cummins, David G.	"	Griffin
Dobson, Jim W.	"	Blairsville
Forbes, Ian, Jr.	"	Tifton
Monson, W. G.	"	"
Powell, Jerrel B.	"	"
Taliaferro, Charles	"	"
Smart, W. W. G., Jr.	"	Griffin
Wells, Homer	"	Tifton
Wilkinson, Stanley R.	"	Watkinsville
Wilson, Clarence	"	Atlanta
Buker, Robert J.	Indiana	Lafayette
Wedin, W. F.	Iowa	Ames
Buckner, Robert C.	Kentucky	Lexington
Jacobson, Don R.	"	"
Taylor, Norman L.	"	"
Taylor, Timothy H.	"	"
Templeton, W. C., Jr.	"	"
Thompson, Warren C.	"	"

Allen, Marvin	Louisiana	Franklinton
Ellzey, H. D.	"	"
Owen, C. R.	"	Baton Rouge
Mondart, C. L., Jr.	"	"
Carlson, Gerald E.	Maryland	Beltsville
Gordon, C. H.	"	"
Henson, Paul R.	"	"
Hollowell, E. A.	"	Port Republic
Hovin, Arne	"	Beltsville
Kreitlow, Kermit W.	"	"
Leffel, Robert C.	"	"
Lewis, Charles F.	"	"
Bennett, Hugh W.	Mississippi	State College
Burson, Byron L.	"	" "
Knight, William E.	"	" "
Lusk, John W.	"	" "
Watson, Vance H.	"	" "
Abernethy, C. C.	North Carolina	Greenville
Blake, Carl T.	" "	Raleigh
Burns, Joseph C.	" "	Raleigh
Busbice, Thad H.	" "	"
Chamblee, Douglas S.	" "	"
Cope, Will A.	" "	"
Dobson, Sam H.	" "	"
Godfrey, Marvin	" "	"
Harvey, Paul H.	" "	"
Harwood, Dewey G.	" "	"
Hyatt, George, Jr.	" "	"
Lovvorn, Roy L.	" "	"
Lucas, H. L.	" "	"
Mochrie, Richard D.	" "	"
Perrin, Dick	" "	"
Pollock, J. E.	" "	"
Stevens, W. W	" "	"
Timothy, David H.	" "	"
Washburn, J. Dan	" "	"
Woodhouse, W. W., Jr.	" "	"
McCroskey, J. E.	Oklahoma	Stillwater
Muriente, José	Puerto Rico	Rio Piedras
Beinhart, George	South Carolina	Clemson
McClain, Eugene F.	" "	"
Ready, E. L.	" "	Johnston
Barth, Karl M.	Tennessee	Knoxville
Burns, Joe D.	"	"
Edwards, Ned C., Jr.	"	"

Fribourg, Henry A.	Tennessee	Knoxville
Montgomery, M. J.	"	"
Reynolds, John H.	"	"
Dalton, L. Gene	Texas	Plainview
Duble, Richard L.	"	Overton
Holt, Ethan C.	"	College Station
Lancaster, J. Albert	"	Overton
Lippke, Hagen N.	"	Angleton
Maunder, Bruce	"	Lubbock
Riewe, Marvin	"	Angleton
Harris, Louis E.	Utah	Logan
Blaser, Roy E.	Virginia	Blacksburg
Buss, Glenn R.	"	"
Miller, John D.	"	"
Murray, W. Ray	"	"
Polan, Carl E.	"	"
Taylor, Lincoln H.	"	"
White, Harlan E.	"	"
Wolfe, Dale	"	"
Hodgson, Harlow J.	Washington, D. C.	CSRS
Richards, Clyde R.	" " "	"

Southern Forage Physiology and Ecology Work Group

Monday - April 22, 1968 - Morning

Review of Influence of Physical Management on Growth and Regrowth after Harvest of Sorghums, Sorghum-Sudangrass Hybrids and Pearl Millets - Ned C. Edwards, Jr., and Henry A. Fribourg, University of Tennessee

This review is concerned primarily with the effects of physical management on the dry matter production of millet, sudangrass, sorghum-sudangrass hybrids, and forage sorghums. The physical managements which will be considered are: (1) plant populations resulting from variations in either plant seeding rates or row spacings, or both; and (2) cutting managements, which will include height of plants when harvested, height of stubble, and consequently, frequency of harvest.

Seeding Rates

An experiment involving 5 seeding rates of sudangrass and sorghum over a 7-year period was reported by Kiesselbach and Anderson (18). Sorghum was seeded at 25, 50, 75, 100 and 150 lb/A, and sudangrass at 20, 30, 40, 60, and 80 lb/A. The corresponding relative yields were 100, 110, 106, 113, and 114% for sorghum, and 100, 101, 105, 106 and 107% for sudangrass.

Odland et al. (24) reported that higher yields of sudangrass were obtained from 40 lb/A than from 25 lb/A seeding rates.

Crowder and Rutger(8) reported on a study in which 2 sudangrasses and a sorghum-sudangrass hybrid were seeded at 10, 30, 50, and 75 lb/A in 7-inch rows. They found no significant difference in dry matter yield among the seeding rates. Stem counts made after the first harvest revealed no significant difference in the number of stems, with the exception of thinner stands for the two sudangrasses sown at 10 lb/A. They concluded that the thinner stands tended to tiller more than the thicker stands.

This also was reported in work by Ratnaswamy (26) in India, working with Italian millet. He found that when a 'tillering' variety was planted in rows with 1, 2, 4 or 8 inches between plants within the row, the wider spacing resulted in more tillers.

In 1965, Holt (14) showed that the yield of the first harvest could be increased almost in a straight-line relationship by increasing the rate of seeding from 7 to 50 lb/A, but that when several harvests were made, seeding rate had little effect on the total yield. He suggested that seeding rates might depend upon the intended use, since higher seeding rates would give higher first-cut yields. However, if several cuts were to be made, with the first one in an immature stage, then seeding rate would not be too important. In another experiment, Haygrazer, a sorghum-sudan hybrid, was planted in 12-inch rows at 20 and 50 lb/A. He found that when the first harvest was made at an immature stage, high seeding rates were not necessary for highest yields.

In a third experiment, the same investigator reported that seeding in twin rows 12 inches apart on a 40-inch center resulted in no yield advantage over a single row on 40-inch centers.

Row Spacing

Fribourg in 1967 (11) reported on an experiment with Gahi-1 pearl millet and Piper sudangrass seeded at 3 row spacings of 7, 21, and 36 inches. The rate of seeding was a constant 0.54 pound per 1000 feet of row. He found that increasing the width of row decreased the yield of these two grasses.

Hoveland and McCloud (16) in Florida found that spacing rows 19 inches instead of 38 inches apart increased yield of dry matter of Gahi-1 pearl millet.

Sullivan (28) in Pennsylvania found that forage sorghums drilled in 7- to 12-inch rows yielded 1.7 T/A more dry matter than 40-inch rows. The average for 1958 and 1959 was 5.61 T/A in wide rows and 7.29 T/A in narrow rows. He maintained a constant density of 1 plant for each 3 inches of row in all spacings

Hart and Burton (12) reported that Gahi-1 pearl millet planted in 24-inch rows or 36-inch rows yielded more than pearl millet planted in 7-inch rows in a season of normal rainfall, less in a season with above-normal spring rainfall, and the same in a very dry season.

Rate of Seeding and Row Spacing

Holt (14) in 1965 reported on an experiment with sweet sudangrass planted in 40-, 20-, and 10-inch rows at 4 to 32 lb/A of seed. Two harvests were made, one at the flowering stage and the other at the end of the season. The average production for 3 years reflected little effect of the seeding rate on the forage production. If the row spacings were averaged over seeding rates, there was an increase in forage production in narrow rows over wider rows. This increase was expressed almost entirely in the first harvest, at which time tillering had not developed to any extent.

Further work by Holt (14) with sweet sudangrass planted in rows at 7 to 28 lb/A or broadcast at 20 to 50 lb/A indicated that rows yielded more than broadcast. The yields for seedings in rows, averaged over seeding rates, was 6255 lb/A, compared to 5310 lb/A for broadcast seeding.

Craigmiles et al. (7) compared the dry matter yield of browntop millet, Tift sudangrass and Starr millet seeded by 3 methods: broadcast at 30 lb/A, drilled at 15 lb/A, and planted in 3-foot rows at 7 lb/A. The broadcast and drilled crops produced significantly more dry matter than the row-planted plots, when averaged over all 3 varieties. The drilled plots resulted in a non-significant increase over the broadcast. This difference was attributed to soil compaction and conservation of moisture around the germinating seeds, resulting in quicker seedling emergence and better stands. In another experiment, Tift sudangrass and Starr millet were drilled at 6-, 12-, and 24-inch row spacings at rates of 3, 6, and 12 lb/A. They found that there was no significant differences in yield due to seeding rate with Starr millet, but Tift sudangrass seeded at 12 lb/A produced significantly more than that seeded at the rate of 6 lb/A.

Stickler and Laude (27) found that increasing row spacing from 20 to 40 inches and population densities from 25 to 50 thousand plants per acre had no significant effect on the silage yield of sorghums. They found also that plants at the higher populations had finer stems and fewer tillers than those in less dense populations.

Burger and Campbell (5) drilled and broadcast Piper sudangrass at rates of 12, 18, and 24 lb/A. The average plant density for the drilled plots was 17 plants per square foot, compared to 10 plants per square foot for the broadcast plots. The average yield of the drilled plots, 5.78 T/A, was significantly greater than that for the broadcast plots, 4.85 T/A.

In another part of the study, 4 sudangrass varieties were seeded in 8-inch drill rows at 12, 24, 36, and 48 lb/A. No significant yield increases were realized from seeding rates in excess of 12 lb/A.

Tourte and Fauche (29) working with millets sown at varying seeding rates and in rows spaced 1, 1.5 and 2 meters apart, found that rows spaced 1.5 meters apart resulted in higher yields.

Holt (13) in 1954 reported seeding sudangrass in 8-inch drills, 40-inch rows, and broadcast at various seeding rates. Although there was no significant difference, numerically the highest yields were produced from drilled plots, 4160 lb/A, followed by 40-inch rows, 4080 lb/A, and the broadcast plots, 3810 lb/A.

Ramaiah (25) in 1960 reported on a study in which Gahi-1 pearl millet was planted in 7-, 21-, and 36-inch rows, at 2 seeding rates. He used a 'normal' seeding rate of 41.6, 13.8, and 7.7 lb/A, for the various row spacings, and double the normal seeding rate. All plots were harvested when 30 inches tall, leaving a 6-inch stubble. He found that plants grown in 36-inch rows produced less per acre than those grown in 21-inch rows; these in turn produced less than those grown in 7-inch rows. The 36-inch row plots at the normal seeding rate produced 5275 lb/A dry matter, the 21-inch rows produced 7350 lb/A and the 7-inch rows, 9460 lb/A. Doubling the normal seeding rate gave no significant increase in yield. Although the highest yield per acre was produced by the plants in the 7-inch rows, the highest production per plant was in the 36-inch rows. The wider rows resulted in plants which were taller than those in the 7-inch rows. The wider row spacing resulted in faster regrowth of the individual plants. This was attributed to less competition from the other plants.

Spacing of 36 inches with normal seeding rates produced the highest number of tillers over the season. The smallest number of tillers was produced in the 7-inch spacing with double the normal seeding rate. Ramaiah concluded that the 7-inch rows were superior in forage production to any of the wider rows.

Management

The cutting management applied to the grasses has been shown by many workers to affect either directly or indirectly, yield, yield distribution, regrowth and tillering. Many other factors, such as crude fiber, protein content, digestibility, and animal intake also are affected. However, these might be considered

or discussed in relation to quality and will not be covered in this review.

Cutting management can be varied in either the height in which plants are grown before cutting and/or the height of stubble left. These heights in turn influence or determine the stage of growth at harvest, the frequency of cutting, and/or the number of harvests made during the season. Since most of the cutting management experiments tend to vary both of these factors together, no attempt will be made to consider them separately.

Burger et al. (6) in 1958 reported an experiment on the effect of time and the frequency of cutting on the yield of sudangrass. They found that when sudangrass was cut at an early bloom stage, the yield was 5.76 T/A. When harvested at a 'pasture' management, 18 to 20 inches tall, a yield of 3.8 T/A was reported. A 2-inch stubble height was used in all cutting managements.

In 1961 Mays and Washko (20) reported that when Piper and Greenleaf sudangrasses and Gahi-1 and common pearl millets were cut from a height of 18 to 20 inches to stubble heights of 2, 4, 6 or 8 inches, highest dry matter production per acre was obtained from a 2- or a 4-inch stubble height. Greenleaf sudangrass yielded slightly more when cut at 4 inches, while Piper sudangrass and pearl millets yielded slightly more when cut at 2 inches. They noted that the small amount of forage removed when the plants were cut to a 6- or 8-inch stubble resulted in a greater number of harvests, and they questioned the practicality of this management.

Kramer and Loden (19) in 1963 compared 14 sorghum hybrids and blends under 3 cutting managements at 2 locations. Cuttings were made at heights of 2 and 4 feet and at a silage stage of growth. Dry matter per acre increased with increases in interval between cuttings.

Worker and Marble (30) working with Brawley forage sorghum, Piper sudangrass, and Sudax SX-11 sorghum-sudangrass, found that dry matter production per acre increased with increasing maturity. The stages of maturity were a 'pasture' stage at 36 to 40 inches, boot, full flower and soft dough.

Dudley (9) in 1963 reported that delaying the initial forage harvest of 5 sudangrasses for 2 and 4 weeks after the appearance of seed heads resulted in a first harvest yield of 4800 and 6550 lb/A, respectively, compared to 1880 lb/A when harvested at the appearance of seed heads.

Hoveland and McCloud (15) working with Gahi-1 pearl millet, reported yields of 13000 lb/A of dry matter when plants were cut from 54 inches of growth to a 4-inch stubble and of 8000 lb/A when cut to an 18-inch stubble; when plants were cut from 30 inches to a 4-inch stubble, a yield of 9000 lb/A was reported, compared to a yield of 8800 lb/A when cut to an 18-inch stubble. They concluded that forage production increased when plants were permitted to grow taller before clipping. Frequent defoliation generally decreased the yield throughout the season. Height of stubble had no influence on the yield of plants clipped at 12, 18 or 30 inches, but 54-inch tall plants were affected adversely by the height of stubble.

Muroga et al. (21) in Japan found that cutting sudangrass at a 5-cm stubble produced higher total dry matter than when the plants were cut at a 15-cm stubble.

Norman (23) in Australia studied Roma sudangrass, and Katherine and Gahi-1 bulrush (pearl) millets, cut at a 2-inch stubble. He subjected the plants to 4 intensities of cutting managements: 1) cut at 4, 8 and 12 weeks, 2) cut at 8 and 12 weeks, 3) cut at 4 and 12 weeks, and 4) cut at 12 weeks after sowing. He found that dry matter production decreased with increasing cutting frequency.

In Nigeria (22) fodder sorghum produced more dry matter in one cutting 11 weeks after planting, than in two cuts 7 and 17 weeks after planting.

Bajai (1) in Hungary reported that sweet sorghum produced more aftermath regrowth when harvested before the panicle developed. He commented that the loss in yield due to the earliness of the first cutting would be compensated by the good development of aftermath growth.

Holt (14) in 1965 working with sweet sudangrass and Sudax SX-11 cut at 2 stubble heights, 6 and 12 inches, and 3 stages of maturity, 24 to 36 inches, boot and flowering, reported that dry matter yields increased as maturity advanced. When managements were averaged over stubble heights, he reported yields of 5880 lb/A for sudangrass at 24 to 36 inches, compared to 6440 lb/A for the boot stage and 7640 lb/A when cut at flowering stage. SX-11 produced 7420 lb/A at the 24 to 36-inch stage, 9220 lb/A at boot and 10890 lb/A at flowering. Height of stubble had less effect on yield than either frequency of cutting or variety. Sweet sudangrass appeared to be favored by a 12-inch stubble height, but SX-11 showed no consistent response to stubble height management.

In another study Holt (14) compared 4 varieties of sudangrass, 2 sorghum-sudangrass hybrids and 2 weak perennial sorghums, cut at 3 stages of growth. He concluded that the forage yield of the sudangrass harvested at an immature stage prior to boot resulted in approximately 50% as much forage as when harvested in the hard dough stage. The sorghum-sudangrass hybrids produced 35% as much forage when harvested in the immature stage as when harvested at late maturity. The dry matter yield of Greenleaf sudangrass for the pre-boot stage was 1.8 T/A, 3.0 T/A for the boot stage, and 3.9 T/A for the hard dough stage. Sudax SX-11 yielded 3.5 T/A when harvested in the pre-boot stage, 4.5 T/A in the boot stage, and 6.8 T/A in the hard dough stage.

Fribourg (11) reported on the management of Gahi-1 pearl millet in 1967. The 7 management schemes applied to plants of Gahi-1 were: 20-1, 20-3, 20-6, 30-1, 30-6, 30-10, and early bloom -4. (The number to the left of the hyphen represented the height of growth, and the second the height of stubble, in inches.) The data showed that, as the height of stubble was increased, not only was the total dry matter increased, but also the leafiness of the material produced. Decreases in defoliation intensity resulted in different levels of total production and leafiness, but they also affected the distribution of this production over time. When 20-inch growth was cut to 3-inch stubble, most of the production occurred in late June, July, and early August. By changing the stubble height from 3 to 10 inches, production was maintained into mid-September.

Fribourg (10) in 1963 reported that Piper sudangrass was not as sensitive to stubble height management as was Starr pearl millet, and that Starr was less sensitive than Gahi-1. He recommended that Gahi-1 pearl millet should not be cut lower than 8 inches, and sudangrasses not be cut lower than 6 inches, if much regrowth after cutting was desired.

Broyles and Fribourg (4) in 1959 reported that Gahi-1 pearl millet produced most when cut at early-bloom to a 4-inch stubble. Successively smaller yields were obtained from treatments where 30-inch growth was cut to a 10-inch stubble, 30-inch growth to a 6-inch stubble, and 20-inch growth to a 6-inch stubble.

Ramaiah (25) by studying the effects of cutting management on the morphology of Gahi-1 found that the dry matter yields did not differ in any of several treatments which varied in defoliation intensity from a 20-3 management to an early bloom-4 management. This appeared to be in contrast to what some other workers have reported. The treatments had marked effects on the leafiness, tillering and general vigor, and nature of regrowth.

Jung and Reid (17) found that increases in sudangrass maturity increased yield. In order to study yield of aftermath growth, they harvested all plants in a head-emergence stage for the first harvest. The regrowth was harvested at 12, 18, and 24 inches, at head emergence, and at full bloom. Total seasonal yields generally increased with each advance in maturity.

Beaty et al. (2) working with Piper sudangrass, Gahi-1 pearl millet, and Sudax SX-11, where 1/3, 1/2, 3/4 or 7/8 of the plant were removed every 2, 3, 4, or 5 weeks, found that harvesting at 5-week intervals produced 46% more forage than harvesting at 2-week intervals. Harvesting 7/8 of the forage increased the production 18% over that obtained by harvesting the top 1/3 of the plant.

Beuerlein et al. (3) in 1968 reported that when plants of Sudax SX-11 were not harvested until hard dough stage of maturity, they produced approximately 17000 kg/ha. When plants were cut to a 6-inch stubble on 4 occasions when they reached 30 inches, and then allowed to grow to maturity, the regrowth was approximately 4000 kg/a. They concluded that increasing the number of harvests reduced dry matter production potential. This was attributed to stand reduction and general loss of vigor by the plants.

Summary and Conclusions

Although the data reviewed do not all agree, the following general conclusions may be drawn:

(1) Although seeding rate may affect the yield of the first harvest, it is not too important a determinant of total yield. This is related probably to the tillering habits of these plants, which compensates for differences in stands.

(2) Narrower row spacings generally result in higher yields than wider row spacings. Broadcast seedings yield no more, and often less, than drilled rows.

(3) Yields of dry matter per acre in general increase with the stage of maturity to which the plant is allowed to grow before cutting.

(4) When plants are cut in a vegetative stage of growth, there generally is a smaller response to low stubble heights than when plants are allowed to grow to a more mature stage. Pearl millet appears to be more sensitive to low stubble heights than sudangrass, and sorghum-sudangrass hybrids are intermediate in their reaction.

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Joint Program of Southern Forage Physiology and Ecology
Work Group and Southern Forage Breeders Group

Monday - April 22, 1968 - Afternoon

Genetic Variability in Sorghum x Sudangrass Hybrids - Gene Dalton, Pioneer Sorghum Company, Plainview, Texas.

The cultivated species of Sorghum belong to the series sativa and Snowden (1936) subdivides this series into six subseries, 31 species and 160 varieties (Table 1). Since there is no apparent barrier to gene exchange between subgroups in the sativa series, it is thought by other workers to be more feasible to consider this group as one species with several subspecies and varieties (Doggett, 1955; Celerier, 1959). Laubscher (1945) made a detailed genetic study of the relationships of taxa in the sativa series and found several inheritance patterns of interest: (1) factors are largely monofactorial, but closely linked, (2) monofactorial factors are influenced by modifier genes and modifier complexes differ between taxa, (3) similar phenotypic conditions in different taxa sometimes behave different genetically, (4) collapse of dominance in certain genetic backgrounds. A study by Kidd (1956) would support the idea that differences exist between species in sativa since he found that parental types could be recovered easily while intermediate types were not recovered in the cross S. cafforum x S. durra.

In the spontonea series, comprising the wild species of Sorghum, Snowden (1955) recognized 17 species which hybridize with cultivated forms (Table 2). One species in this series, S. sudanensis, has been used commercially. There are no barriers to crossing between the cultivated forms and sudangrass. Doggett (1965) suggests that sudangrass has been influenced by introgression from cultivated sorghums. As much as 70% outcrossing has been observed in sudangrass (Garber and Atwood, 1945) and unselected sudangrass is found to be a highly heterogeneous mixture of different plant types (Quimby and Martin, 1954).

The Sorghum genus represents a wide range of different types which can be hybridized to some degree. Genetic diversity is almost limitless and plant breeders have established true breeding varieties distinctly different in type in all parts of the world where Sorghum is grown.

With the advent of hybrids, plant breeders were able to utilize any part or all of the variability contained in the sativa and spontanea series when the sorghum x sudangrass hybrid, a unique summer annual grass, was developed. Hybrids of this type are currently made in quantity using cytoplasmic sterility, as the breeding tool (Stephens and Holland, 1954).

Dr. Maunder has discussed the utilization of sorghum x sudangrass hybrids and characteristics of this crop. Some duplication may occur in the following discussion, but the aim here is to signify those general areas where genetic variability has been recognized in the sorghum x sudangrass hybrid.

Types of hybrids possible. Three combinations can be made which differ in their characteristics:

A. Sudangrass x sudangrass - This hybrid has a narrow genetic base since only sudangrass is involved. It is fine stemmed, very leafy, with good regrowth and resembles sudangrass varieties in type.

B. (Sorghum x sudangrass) x sudangrass - This hybrid has a wide genetic base and approaches sudangrass x sudangrass hybrids in plant type.

C. Sorghum x sudangrass - This hybrid has a wide genetic base, is broad leafed and thick stemmed. The grassy characteristic is evident in the hybrid and regrowth is good.

Disease Resistance. The original sudangrasses introduced into the United States were not highly resistant to diseases, but plant breeders successfully selected varieties which are resistant to several diseases. Resistance to several diseases is known in grain sorghum varieties and many diseases can be effectively controlled by the proper choice of parents for the sorghum x sudangrass hybrid.

Prussic Acid Poisoning. A lethal level of hybrocyanic acid (HCN) has been recognized to exist in some sudangrass varieties, sorghum x sudangrass hybrids, and grain sorghum varieties for many years. HCN content is reported to be a heritable trait (Franzke et. al., 1939; Hogg and Ahlgren, 1943). However, the level of HCN can be influenced by fertilizer and management, but considerable controversy has existed on this subject (Franzke et. al., 1939; Menges, 1945; Williaman and West, 1915; Patel and Wright, 1958; Couch et. al., 1939; and others).

Low HCN types have been selected in sudangrass varieties, but no low HCN types are known in the grain sorghum varieties. A cross between a low HCN sudangrass and grain sorghum is usually intermediate in HCN content. Most sorghum x sudangrass hybrids have an HCN content above the suggested safe level, but this level is not clearly defined. It will be necessary to make gene transfers of low HCN content to grain types or alternatively, discover a low HCN grain from the World Sorghum Collection before the HCN problem can be effectively solved in sorghum x sudangrass hybrids.

Forage quality. No definitive quality standard has been developed for forage. Gangstad (1964) studied palatability in sorghum x sudangrass hybrids as a measure of quality. Differences between hybrids were observed. Positive relationships with palatability appear to be associated with leafiness, potassium level, crude protein, fats and total sugar, but a negative relationship was found with carbohydrate level (mostly starch). In the past, analytical evaluations were made to estimate quality of forage, but these analyses have not been completely satisfactory. More recently, rumen analyses techniques, en vivo and en vitro, are being developed to evaluate forage. Some of the new techniques look promising but at present, our only true evaluation for forage quality is made by the animals themselves.

Yield. There are several grassy sorghum hybrids of various types on the market. The comparative yield of these hybrids relative to sudangrass is evaluated each year by many cooperative agencies, private and public.

Usually all types of summer annual grasses, sometimes including pearl millet, are evaluated in a uniform clipping test. There is some question that a test of this type accumulates accurate information for all of the various grassy types entered in these tests since proper management for each type is necessary to obtain optimum yields.

Yield is a heritable trait and it should be possible to detect differences between hybrids in a yield test. In my experience with these tests, a difference can be detected between classes (e.g. sudangrass varieties, sorghum x sudangrass hybrids etc.) but seldom between entries of the same class if maturity of the hybrid is considered. In Table 3, the results of a typical uniform clipping test are presented. Differences between hybrids are detected only at the tails of the array. Essentially 11 of the 13 entries are statistically identical. Three reasons are offered to explain this: (1) actual differences between similar types of summer annual grasses are too small to measure; (2) management, in terms of cutting time, water, and fertilization, does not affect all entries in the same way; and (3) our methods are not refined enough to measure the inherent differences between hybrids.

Data were collected at Plainview, Texas, in 1966 and 1967 from a uniform clipping trial. In Figures 1 and 2, graphs have been prepared which depict the distribution of tonnage over cuttings for each type of grassy hybrid. These graphs suggest that time of cutting has an influence on the performance of different types of summer annual grasses. In addition to type of hybrid, the maturity of the hybrid in relation to clipping is important. The elongation of the internodes occurred after floral initiation and completion of this elongation phase before cutting is essential for maximum yield.

Sudangrass varieties appear somewhat linear for tonnage per cutting in both years. Sudangrass x sudangrass hybrids are similar to sudangrass in forage distribution over cuttings. Sorghum x sudangrass accumulates tonnage early then tapers off in the later cuttings. The grass 3-way cross tends to be intermediate between sudangrass and the sorghum x sudangrass hybrid. Distribution of tonnage for pearl millet is similar to that of sorghum x sudangrass hybrids, but response for pearl millet was influenced by the timing of cutting. Other types were influenced by cutting but to a lesser degree. In 1967, cool July temperatures did not promote growth and the August 11 cutting was made before some types had reached boot stage. The lack of growth during a cool period and the lower total tonnage realized in 1967 as compared to 1966 suggests that growth stops and yield is reduced when night temperatures are below 60°. It is noted that sudangrass types in this test are inhibited to a lesser degree than other types. It is of interest to note here that trends are observed to indicate genetic diversity for yield factors, but many of these differences are confounded by our management practices.

SUMMARY: Variability exists in grain sorghum x sudangrass hybrids for many traits. This variability is being utilized by the plant breeder to make improved sorghum x sudangrass hybrids. The final product may be of several distinctly different types in a general category of summer annual grasses which responds uniquely in the hands of the one who manages the crop.

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TABLE 1

THE CULTIVATED SORGHUMS[1]

Genus: Sorghum — Section: Eu-Sorghum
Subsection: Arundinacea — Series: Sativa

Subseries I. Drummondii
- S. aterrimum
- S. drummondii
- S. nitens

Subseries II. Guineensia
- S. margaritiferum
- S. guineese
- S. mellitum
- S. conspicuum
- S. roxburghii
- S. gambicum
- S. exsertum

Subseries III. Nervosa
- S. membranaceum
- S. Basutorum
- S. nervosum
- S. melaleucum
- S. ankolib
- S. splendidum

Subseries IV. Bicoloria
- S. dochna
- S. bicolor
- S. miliiforme
- S. simulans
- S. elegans
- S. notabile

Subseries V. Caffra
- S. coriaceum
- S. caffrorum
- S. nigricans
- S. caudatum
- S. dulcicaule

Subseries VI. Durra
- S. rigidum
- S. durra
- S. cernuum
- S. subglabrescens

[1] After Snowden, 1936.

TABLE 2

THE WILD SORGHUMS[1]
Genus: Sorghum
Section: Eu-Sorghum

Subsection: Arundinacea Series: Spontanea

S. virgatum	S. panicoides	S. brevicarinatum
S. lanceolatum	S. sudanense	S. usambarense
S. vogelianum	S. niloticum	S. castaneum
S. aethiopicum	S. macruchaeta	S. hewisonii
S. arundinaceum	S. somaliense	S. elliotii
S. verticilliflorum	S. pugionifulium	S. stapfi

Subsection: Halepense

S. halepense	S. randolphianum
S. miliaceum	S. propinquum
S. almum	S. controversum

[1] After Snowden, 1955 and Celerier, 1959.

TABLE 3

Uniform Clipping Trial for Summer Annual Grasses
Plainview, Texas 1967

ENTRY	YIELD[1] tons dry matter per acre
1	28.59
2	28.20
3	28.02
4	27.20
5	26.86
6	26.55
7	26.53
8	26.50
9	26.48
10	26.33
11	25.21
12	24.03
13	22.49

[1] Tested by Duncan's new multiple-range test.

Figure 1. Forage per Cutting of Summer Annual Grasses for Three Cuttings at Plainview, Texas 1967.

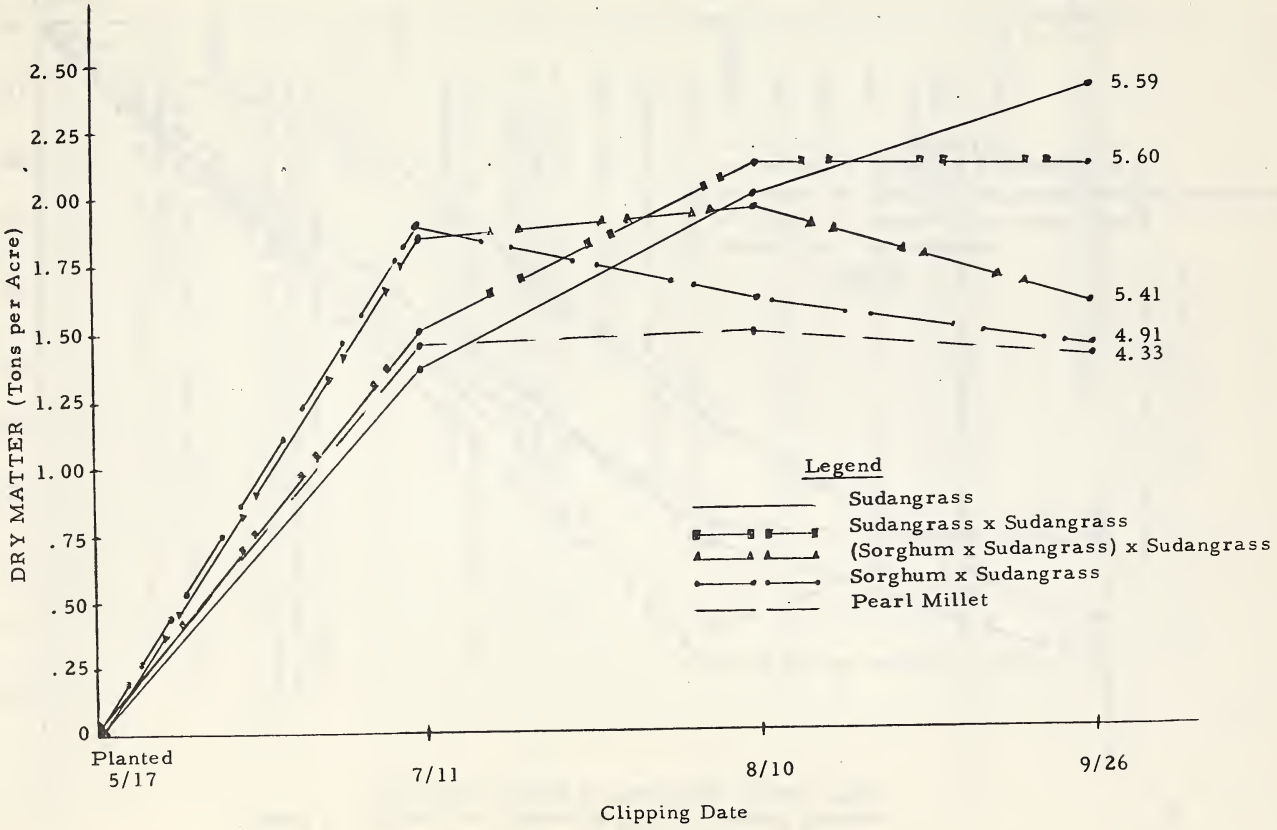
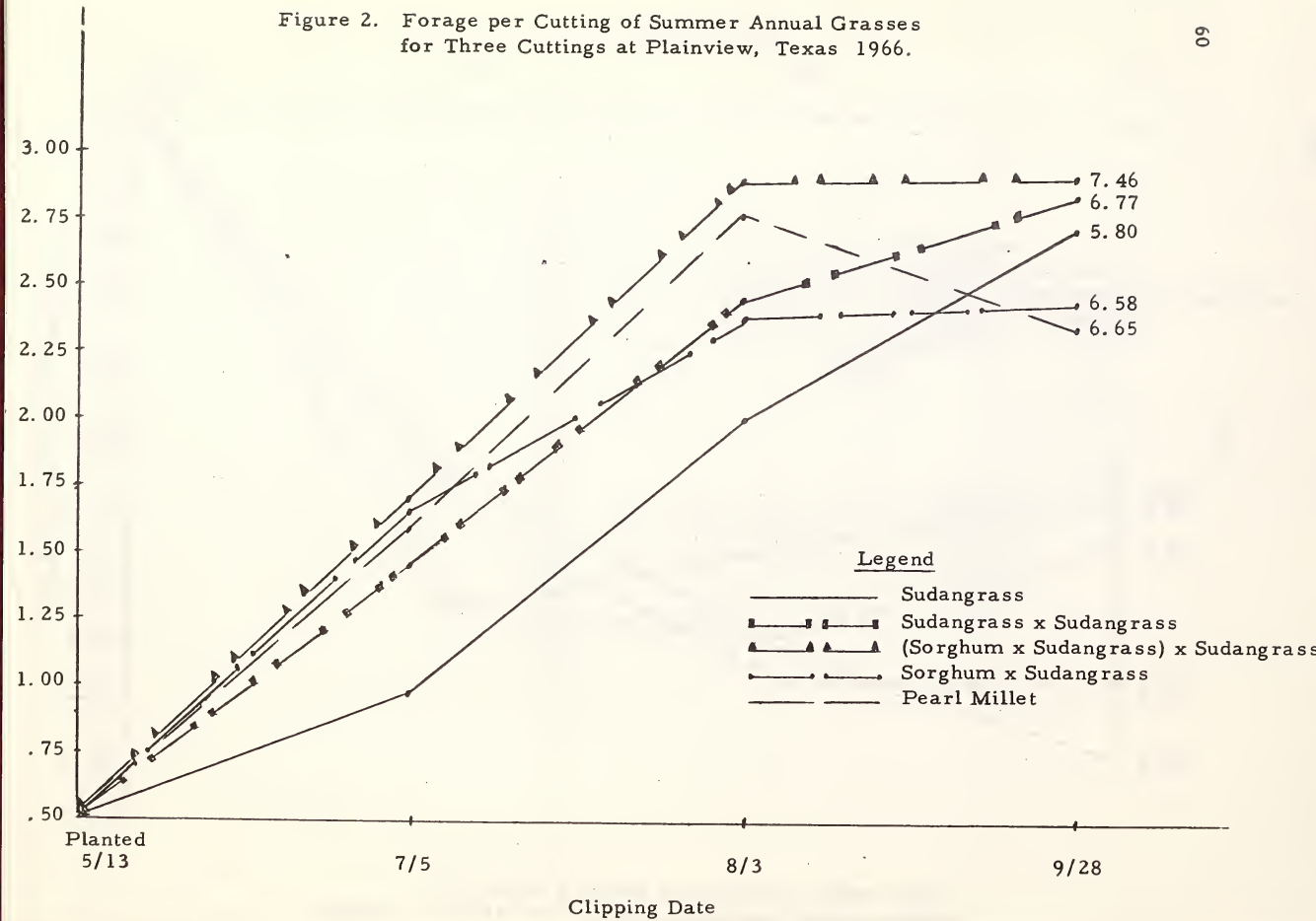


Figure 2. Forage per Cutting of Summer Annual Grasses for Three Cuttings at Plainview, Texas 1966.



Extension Work Group

Monday - April 22, 1968 - Afternoon

North Carolina Forage Program Extension - S. H. Dobson, Extension Specialist in forages, North Carolina State University

I. Trends

A. Livestock Nos.

1. Dairy - numbers down - milk production up with 2561 Grade A dairies and 327,000 dairy cattle including Grade C producers.

2. Beef - numbers up - 50% last 7 years - 673,000 head.

3. Sheep down.

4. Hogs and poultry no longer forage consumer in this State.

B. Forages

1. Improved pastures - up - 1,200,000 acres now.

2. Unimproved pastures - down - 700,000

3. Hays - down - 700,000 tons

a. Alfalfa - down, 80% but will start back in 1970
b. Lespedza - down - will continue
c. Red clover - up - will continue

4. Silage - up - acreage and yield - 115,000 acres - 13 tons/acre yield - this will continue.

II. Program

A. Agent Training

1. Week forage school for all forage agents every 5 years.
2. One day each year on current research and farm practices.
3. County visits - 2 hours with each agent each year reviewing current trends.

B. Mass

1. Triple F - Fast rotation, using slides, posters, fliers
2. Grassland Newsletter
3. Movie on aerial topdressing - "Pastures from the Sky"

completed this year.
4. Forage Memos - trend is to short easily changed leaflets using offset printing

C. Variety Testing - under extension - a man full-time - specialist, Mr. Washburn with Dr. Blake as supervisor

D. Turf - demands increasing - Carl Blake now devoting 10% of time - (a new position next year - we hope)

E. Teaching -

1. Classroom - a semester course in pastures and forage crops is taught each year to the Ag. Institute group.
2. Graduate students are assigned to extension specialists now.

F. On-the-Farm Tests - moving in this direction - have hired a research assistant. Going on practical farms and trying to get animal response and economic evaluation of specific treatments. Also with animal and farm management specialists getting animal enterprize analyses.

III. 4-H

A. Demonstrations - Have good county demonstration work

B. Project Work - weak, we will be trying to strengthen this phase.

IF-PUP - Intensified Forage Production and Utilization Program - Joe D. Burns, University of Tennessee.

About 10 million acres of land in Tennessee are used for crop and pasture production. According to the 1964 census of agriculture, 6 million acres were used for hay and pasture. The 1964 census also shows approximately 2.1 million head of cattle on Tennessee farms. Of this number there were 370,000 dairy cows, 756,000 beef cows, and 1 million head of other cattle including steers, heifers, bulls and calves.

The Tennessee Soil and Water Conservation Needs Inventory suggests that for best conservation and long-term income producing use, approximately 4.3 million acres should be in sod cover annually. An estimate of the acreage needed to produce the forage for the 1964 livestock inventory was approximately 4.3 million acres. This needs estimate is based on an efficient forage production program which means upgrading the present production rate.

It is possible to provide the forage needs for this livestock inventory on 4.3 million acres. If this is accomplished, it will then be possible to add to Tennessee farm income by growing a higher income producing crop on the approximately 1.7 million acres remaining and/or expanding the Livestock Industry. This adjustment can add $80 to $100 million gross income plus the income which will be added by more efficient dairy and livestock production

through the improved feeding programs with present cattle population.

The following general steps have been taken to initiate IF-PUP:

I. Forage production and utilization recommendations were reviewed and revised by experiment station, teaching and extension personnel. The following departments were involved: Dairy, Animal Husbandry, Agricultural Biology (entomology and pathology), Agricultural Engineering, Agricultural Economics and Agronomy.

Committees and subcommittees were established to consider specific recommendations. The recommendations are University of Tennessee recommendations.

A. Animal Husbandry

1. Cow-calf
2. Steer and heifer feeding
3. Steer and heifer grazing

B. Dairy

C. Ag Economics
1. Budgets

D. Agronomy

1. Fertility and land use
2. Varieties - Seeding rates and dates and mixtures
3. Harvesting and storing, stage to harvest
4. Insects and diseases
5. Weed control

II. University recommendations were presented to all men agents in each Extension District (5) in a one-day inservice training session by members of the Extension Animal Husbandry, Dairy, Ag. Economics, and Agronomy Departments, accompanied by administrators.

III. Suggestions were presented to agents for organizing county IF-PUPS.

A. Meetings with professional agricultural workers.
B. Meetings with seed, fertilizer and machinery industry.
C. Meetings with livestock and dairy organizations.

IV. Major emphasis was placed on demonstrations:

A. Pasture Renovation (putting clovers back in grass pastures)
B. Soil Test Fertilization of Pastures
C. N-P-K - attention getter (Large letters fertilized on grass hillsides)
D. Stage to harvest hay

E. Midland bermudagrass establishment (weed control and fertility)

V. Field tours, meetings, pictures, news articles, radio and TV programs are being used to publicize IF-PUP.

FORAGE AHEAD WITH MEAT AND MILK!

The Pasture and Forage Crop Program in Kentucky - Warren C. Thompson, University of Kentucky.

Forages (pasture, hay, and silage) occupy some 9.5 million acres (65% of agricultural cropland) in Kentucky; 1967 estimated income from meat, milk and cash feed from this acreage was 315 million dollars. To make these forage acres more productive is the basic purpose of the forage program. Four action areas are the nucleus of the program. 1) Forage Councils: There are 60 county, 5 area, and a State Forage Council. Their purpose is to help evaluate problems, set program priorities, and serve as a "clearing house" to secure teamwork by professionals. 2) Pastures: Emphasis areas are Grassland Renovation, Plant-Animal Management, Species Introduction and Selection, New Seeding Land Use, and Fertility, 3) Hay: The overall goal is consistent high production of quality feed, 4) Silage: The overall goal is high acre yield, total volume, improved quality and full use.

Examples of program influence during the past five years are: 1.2 million grassland acres have been renovated. 2) average per acre yield of hay is up about 1/4 ton per acre and state yield is an all time high, 3) total silage has increased about 500,000 tons and acre yield is up 10%, 4) The number of farmers fertilizing pastures and hay crops regularly has increased 53%, 5) Alfalfa acreage due to invasion of the alfalfa weevil has been reduced 40%, yet per acre yield is up about 20% so that the net loss in tons harvested is off only 24%, 6) Clover and grass hay harvested has more than compensated for the net loss from alfalfa. 1.2 million tons were harvested in 1967 as compared to 3/4 million tons in 1962.

Commonwealth of Puerto Rico State Pasture Program - José E. Muriente, University of Puerto Rico.

Pasture is one of our principle agricultural enterprises with the greatest acreage devoted to it. Over 1,000,000 acres or more than 50% of all the land is grassland of which 460,000 acres are cultivated, the rest may be considered range. Our expanding dairy and beef cattle industries need more and better pastures. Grain feeds are imported. There is money in the production of good pasture crops. Where rainfall is over 45 inches yearly or where irrigation is used profits per acre in well cultivated and well managed pastures are high.

To induce improvement in grassland cultivation, a good pasture program with incentives was made by the Federal Department of Agriculture and the Commonwealth Department of Agriculture with the cooperation of Soil Conservation, Experiment Stations and Agriculture Extension Service personnel.

The Pasture Program offers incentives for planting the following grasses Guinea grass (P. maximum), Pangola grass (D. decumbens), Pará grass (Pen. puspureum), Merker (Pen. purpurascens), Signal grass (B. brizantha) and Star bermuda (C. plectostachyus). It gives $40.000 per acre in soils over 30% slope and $30.00 in soils of 30% or less slope, also 300 pounds of fertil izer 14-4-10 and all the lime needed to raise the pH is given to the farmers

The Extension Serv Specialist roll is of great importance in preparing and developing the Past e Program which will give the greatest stimulus in selected grass varieties planting and helping the farmers in the best way. The Specialist must help in determining the goals of the Program and the practicability of it.

One of the major objectives of the Extension Specialist is to develop among field personnel of the Department of Agriculture Vocational Agriculture, and Extension personnels working in the Pasture Program knowledge and understanding of the agronomic practices and latest recommendations in forage crop cultivation and utilization. This is done through training meetings.

Recommendations to farmers are given using mass media as T.V. programs, radio programs, and press reports. Also necessary newsletters and leaflets are prepared and distributed.

The Specialist main purpose is to have the agents up to date in pasture culture so that they may develop a good leadership in their areas with the farmers in the forage crop enterprise.

The Commonwealth goal for 1975 is to have 700,000 acres of good selected varieties of grasses efficiently cultivated.